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ABSTRACT

This publication is intended to be an aid for secondary school science teachers in providing some additional student-oriented activities to enrich the earth science program. These activities have been classroom tested by teachers and have been considered by these teachers to be educationally successful. This publication is a product of the Earth Science Communication Program of the state of Virginia which was funded by the National Institute of Education. The activities introduced cover four areas: (1) astronomy; (2) geology; (3) meteorology; and (4) oceanography. An introductory activity about earth science and society, and suggestions for developing charts are also presented. All the activities are presented in the same way including the purpose, materials, pre-lab activities, procedures and conclusions. Some activities also include charts and/or tables. (HM)

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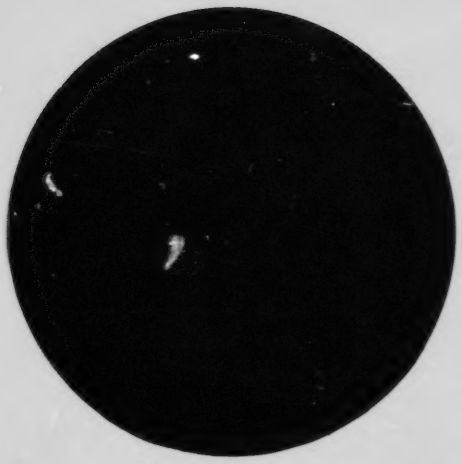

SUPPLEMENTARY ACTIVITIES FOR ENRICHING THE TEACHING OF EARTH SCIENCE

ASTRONOMY
GEOLOGY
METEOROLOGY
OCEANOGRAPHY

Department of Education • Commonwealth of Virginia • Richmond, Va. 23216 • June 1978

SE 027 633

PREFACE

Since November of 1975 the Science Service of the Department of Education has sponsored an Earth Science Communication Program involving department personnel, teacher educators in Virginia colleges and universities, and instructional personnel in Virginia public schools. Beginning in September of 1976, funds from a National Institute of Education Dissemination Special Purpose Project have facilitated and strengthened this effort.

Visible outcomes of the Earth Science Communications Program include statewide and regional conferences, a monthly newsletter entitled IMPART, and a telephone network encompassing earth science educators in the Department of Education, colleges and universities, and local school districts. The publication of this booklet, Supplementary Activities for Enriching the Teaching of Earth Science, represents another significant product of the program and the N. I. E. grant.

One of the objectives of participating earth science educators has been to develop and disseminate materials which will lead to increased activity in earth science classrooms. The activities in this booklet, many of which were offered by classroom teachers, are significant contributions in this regard. Appreciation is expressed to all who contributed activities for inclusion in this publication.

Special recognition must be given to Dr. Joseph D. Exline, Assistant Supervisor of Science, for his leadership of the Earth Science Communication Program and to Mr. Roy T. Lewis, Jr., Supervisor of Data Utilization and Reporting, for his assistance in administering the N. I. E. Special Purpose Grant.

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INTRODUCTION

With the present societal concerns relating to environmental-energy problems, the significance of earth science in the secondary school program should be all the more apparent. Without a sound understanding of many of the earth processes and how man impinges upon these processes, the high school graduate will not be adequately equipped to deal with many of the environmental-energy related concerns. There must be concerted efforts to develop quality earth science programs which will provide the foundation necessary to equip all students to better understand these important earth processes. . . our future well-being depends greatly upon this knowledge.

In addition, earth science must be taught in a manner that will encourage the student to become a life-long learner, to define and pursue important questions, to seek appropriate answers, and to make reasonable choices. This approach demands that the student becomes actively involved in the teaching-learning process. For the earth science program to be most educationally effective for the student, it should be well balanced with inquiry oriented laboratory and field experiences.

This publication is intended to be an aid for the teacher in providing some additional student-oriented activities to enrich the earth science program. These activities have been classroom tested by some teachers and have been considered by these teachers to be educationally successful. However, each teacher is encouraged to examine closely each activity before it is used to determine: for what level of student is the activity most appropriate, what teacher preparations are necessary, what materials must be available, where and when can the activity be used to achieve maximum benefit for the student, and do the materials need to be altered for student use.

Finally, this publication is also intended to be an extension of a phase of IMPART. It has come about because individuals around the State have been willing to share some of their ideas. A special appreciation is extended to these individuals. Future expansion of this publication is possible through the monthly IMPART, if individuals around the State will continue to share some of their teaching ideas.

Joseph D. Exline, Editor

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The development of this publication was made possible by a grant from the National Institute of Education. The material in this publication is not intended to represent points of view or policy of the National Institute of Education.

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SOLAR HEATER POSTER. . . . . Appendix

TITLE: Earth Science and Society

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PURPOSE: This is a year-long activity the purpose of which is to develop gradually an inventory of the ways that knowledge of earth science is important or essential to the solution of present and future economic, political, and social problems of the United States and of the world. It should show the interrelationships between many disciplines and most of human activity. It should indicate the numerous professions and other occupations in which knowledge of earth science is useful or essential.

MATERIALS: Large sheets of newsprint (perhaps 10 to 50 by the end of the year), magic markers in different colors

PRE-LAB: This activity should start at the beginning of the year; in fact it makes a good introduction for the first day.

Set up several sheets of newsprint on a rod or stand so that they can be flipped over as necessary to expose a clean sheet but so that previous sheets can be kept to refer to during the year and to use in a final summary. An easel in the corner of the room is a good arrangement--or a rod with a slit for the paper and a cord for hanging it.

At the top of the first sheet write E A R T H S C I E N C E in large letters. You are ready for class.

(Note: You may decide that it is preferable to have one set of newsprint for each class so that students in the last period will develop their own ideas as much as those in the first. In this case, assign a student to be responsible for rolling it up and storing it at the end of the class period and for hanging it up the next day. You may not need to use it every day but it should be available where a word or two can be added whenever it seems appropriate. At first, you will have to make suggestions but within a few days students will take over most of the responsibility and will have many ideas of things to include on the charts as they develop.)

PROCEDURE:

1. As an introduction help students arrive at a definition of earth science, a list of the principal disciplines included in earth science, and a list of what they expect to be covered under each of these. These original definitions and lists do not need to be comprehensive or even 100% accurate as long as you make clear to them that what they are putting on this first sheet is their preliminary estimate and is subject to revision as they learn more.
2. Tell students that, as the year passes, they will develop an inventory of the ways that the physical earth (materials, processes, position in space) forms a framework for human activity and how knowledge of earth science is important not just to professionals, but to everyone in daily life.
3. Ask students what they have learned about the earliest ages of man--what they were called. Answers will probably be "stone age", or they may mention "cave men". Point out how this is dependent on the nature of the earth-- the physical environment. Go on

to "age of bronze", "age of iron",-- of steel, of coal, of petroleum, even industrial age. Draw from them that each of these was possible because of the availability of special earth materials.

4. Take a minute or two or five to add to the chart every time during the year that work broadens the scope of students' understanding of earth science or the way it impinges on human society and activities. Following are a few examples of the way the charts can evolve, but these are only examples. There should be a great deal of individual input, so actual charts will vary widely depending on experience of the students. You will have to make suggestions when their personal experiences are limited; e.g., students in an urban setting may have difficulty in understanding the importance of slope, or stream processes in the country and how they themselves personally are affected by these-- or, living in a humid region, they may have difficulty understanding conflict over water rights between agriculture, industry, mining, and community needs in arid regions and how decisions regarding these things in Montana affect them in Virginia.
5. As the end of the year approaches, spend a period or two going over all the sheets. Have the students summarize the information in tabular, graphic, or chart form (suggestions below) and prepare a statement which gives their own analysis of the role of earth science in the contemporary world.

CONCLUSION: They should conclude that the composition of the earth and earth processes place ultimate restraints on human society, that all human activities are affected in some way by the earth itself, that human activities can and do greatly affect the earth and earth processes, that knowledge of earth science can help society make the best possible use of planet earth for the good of mankind and of life as a whole.

SUGGESTIONS FOR DEVELOPING CHARTS AND FOR GUIDING DISCUSSIONS

Chart I should be an overview of the field of earth science. It should be prepared at the beginning of the year with ideas students have when they first enter the class. Later it should be modified and revised to include things they have learned and to correct any mistakes they made initially. The original is not expected to be complete or perfectly accurate.

Chart II Series should include one generalized chart for each of the basic disciplines of earth science: A=astronomy; G=geology; M=meteorology; O-oceanography.

A possible format for the Chart II Series is given in Sample CHART II-G, Geology. All of the topics studied should be added to this. Encourage students to return to earlier sections of any of the charts to insert additional information whenever something previously omitted comes up.

Chart III Series should include more detailed breakdown of information covered in some of the more important topics of the CHART II series. For example, MINERALS could become a Chart III heading. Topics under that could be 1) metallic minerals, 2) non-metallic minerals, 3) fuels (not really minerals but you can include them here even though most are of organic origin). Sub-topics then could be such things as: 1) iron, aluminum, copper, etc.; 2) salt, building stone, cement, clays, etc.; 3) coal, petroleum, natural gas, uranium. Or WATER could be a chart heading. Topics could be 1) surface water and 2) subsurface water. For surface water you can have sub-topics of erosion, deposition, flooding, pollution, etc. For subsurface water, controls of ground water movement and supply, nature of ground water, water table, deep aquifers, etc.

It is not essential, or probably even desirable, to make charts for every topic. Guide students to select a few which have major implications to society in numerous ways.

Encourage students to discuss their chart work at home with their parents and with their friends in an effort to broaden the input into the chart and to get their parents and friends thinking about the physical earth and society.

In developing lists of people who need to know, it may help to break them down into categories-- professional people involved in decision-making, planning, working out technical and political arrangements; citizens who must vote on and support plans and decisions.

SUMMARY CHART At the end of the year develop a chart to summarize the information that was recorded during the year. This chart does not need to be done in great detail. The point is for students to do a round up and see all the ways that their daily lives are influenced by natural earth processes and the composition of the earth. Have them develop a list of different types of human activity until you think they have covered the spectrum. List these in the left hand column. In the middle column, have them indicate the major subjects under earth science which affect each activity. In the right hand column, indicate whether the effects are economic, political, social-- local, national, or international.

Again, the sample chart is only a suggestion. There are many other possible forms such a summary chart may take.

EARTH SCIENCE

Sample Chart I

Study of the physical earth and its place in space

ASTRONOMY	GEOLOGY	METEOROLOGY	OCEANOGRAPHY
Sun Moon Solar System Stars etc.	Rocks Minerals Landforms Erosion Earthquakes Soil	Atmosphere Wind Rain Storms Clouds etc.	Ocean basin Water composition Minerals Waves Currents etc.
WHO	NEEDS	TO	KNOW
Astronomers Space Scientists etc.	Geologists Miners Oil Company Employees etc.	Meteorologists Farmers Pilots etc.	Oceanographers Fishermen Sailors etc.

Note: Unless completely wrong, use students' suggestions. List should be limited at first- don't push too hard. Let students add as they learn.

I-4

GEOLOGY

Sample Chart II-G

Topics	Subtopics	Related Sciences	Relation to economic, political, social institutions and activities	Who needs to know
Earth composition	General Rocks Minerals Soil	Chemistry Soil Science Geomorphology Hydrology Geophysics Mineralogy Metallurgy Agronomy Hydrology	Economic- materials for industry transportation, energy, agriculture-employment Political- international trade, decisions on development-mineral rights Social- locations of towns-land use	Miners Lawyers Planners Engineers Farmers etc.
water	Surface Streams Lakes Subsurface	Chemistry Biology Physics Meteorology Climatology Geomorphology Hydrology	Economic- water needs for industry, agriculture, domestic use cost of water supply, flooding, etc. Political- conflicts over water rights- supply and pollution-decisions on use Social- determines types of society and customs- recreation-transportation	Planners Engineers Citizens
Mountain Building	Earthquakes Volcanoes	Seismology Vulcanology Geophysics	Economics Political Social	

I-5

SUMMARY CHART

Activity	Affected by which earth processes or characteristics	Effects are economic, political, or social- local, national, or international
transportation		
education		
agriculture		
construction		
medicine		
fishing		
law		
mining		
industry		
recreation		
housing		
clothing		
communication		

ASTRONOMY

TITLE: Astronomy: Finding the Sun's Altitude

Paul H. Knappenberger, Jr.
Science Museum of Virginia
Richmond, Virginia 23220

PURPOSE: After completing this activity, the student should be able to:

1. measure the sun's altitude;
2. describe how the sun's altitude changes throughout a day; and
3. describe how the noontime altitude of the sun changes throughout the year.

MATERIALS:

1. 21 x 28 cm sheet of cardboard
2. scissors
3. glue
4. Shadow Caster (included)

PRE-LAB: This activity requires observations of the shadow cast by the sun for various times during the day, and for objective (3), for various days throughout a year.

The Earth's daily rotation, its annual revolution (motion along its orbit), and the tilt of its axis all combine to change the altitude (height) of the sun above the horizon. The change in the sun's altitude can be measured with a simple shadow-casting device. These measurements can then be used to discover patterns in the sun's apparent path through the sky. CAUTION STUDENTS TO NEVER LOOK DIRECTLY AT THE SUN.

PROCEDURE: Follow the instructions for making a "Shadow Caster". Glue the device to the cardboard sheet for greater stability. Record the noon altitude of the sun at weekly intervals throughout one year. BE SURE THE SHADOW CASTER POINTS STRAIGHT UP (90° from the horizontal).

CUT TOP

SHADOW CASTER

TOP CUT

FOLD UP ALONG DASHED LINES

ALONG DASHED LINES FOLD UP

CUT NOTCH

SUN LINE

75°
65°
55°
45°
35°
25°
15°

80°
70°
60°
50°
40°
30°
20°
10°

FINDING the SUN'S ALTITUDE

NEVER LOOK DIRECTLY AT THE SUN

SHADOW SCALE

SUN LINE — POINT THE ARROWS TOWARD THE SUN —

1. Cut along top edge as indicated; cut notch in top edge.
2. Fold along dashed line so top edge points straight up.
3. Place the shadow scale in front of you with the sun line pointed toward the sun.
4. Turn the shadow scale so the notch's shadow falls directly on the sun line; be sure the shadow caster points straight up.
5. The shadow of the TOP edge of the SHADOW CASTER will fall on the scale, marking the sun's altitude

Designed by David C. Ulmer of Colorado, Springs, Colo.

TITLE: Astronomy: Finding the Sun's Azimuth

Paul H. Knappenberger, Jr.
Science Museum of Virginia
Richmond, Virginia 23220

PURPOSE: After completing this activity, the student should be able to:

1. define azimuth
2. measure the sun's azimuth
3. describe how the sun's azimuth changes during the day.

MATERIALS:

1. 21 x 28 cm sheet of cardboard
2. glue
3. nail (2 to 5 cm long)
4. Azimuth Scale (included)
5. compass (or other method to locate directions)

PRE-LAB: This activity requires observations of the shadow cast by the sun for various times during the day.

Azimuth is one coordinate used by surveyors, navigators, and astronomers for locating objects. Azimuth is measured along the horizon, beginning at the North point (0°) and increasing towards the East (90°). The azimuth of an object in the South is 180° and towards the West is 270°.

As the sun appears to move across the daytime sky, its azimuth steadily changes. Recording these azimuth changes helps one understand the apparent motions of the sun. CAUTION STUDENTS TO NEVER LOOK DIRECTLY AT THE SUN.

PROCEDURE: Follow the instructions written on the "Azimuth Scale" for finding the sun's azimuth. Record the value of the sun's azimuth at 1 hour intervals during the day.

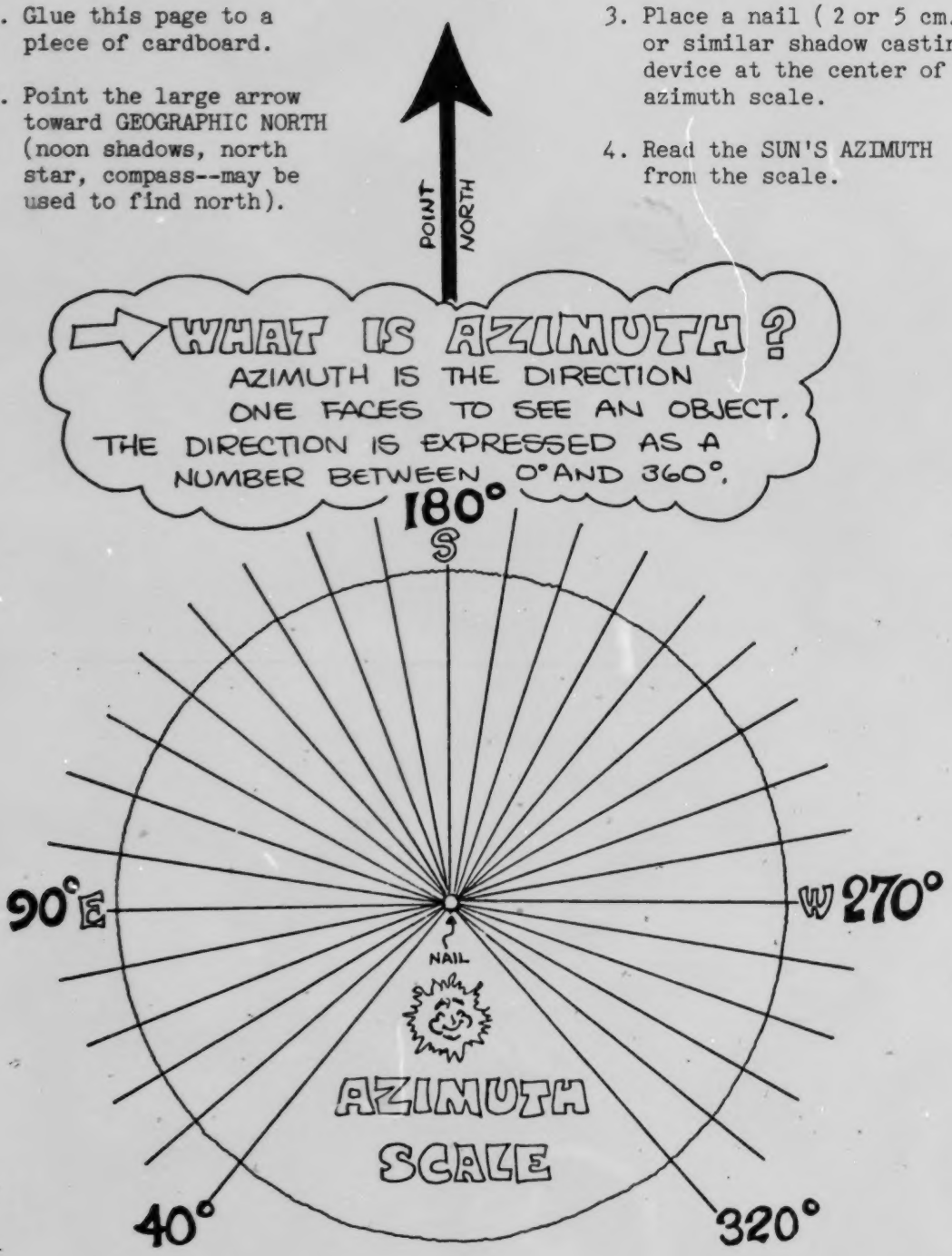
INSTRUCTIONS

1. Glue this page to a piece of cardboard.

2. Point the large arrow toward GEOGRAPHIC NORTH (noon shadows, north star, compass--may be used to find north).

3. Place a nail (2 or 5 cm.) or similar shadow casting device at the center of azimuth scale.

4. Read the SUN'S AZIMUTH from the scale.



Designed by David C. Ulmer of Colorado, Springs, Colo.

TITLE: Astronomy: Using a Sundial to Observe Apparent Motions of the Sun

David C. Ulmer
Mitchell High School
Colorado Springs, Colorado

PURPOSE: After completing this activity, the student should be able to describe how the sun appears to move across the sky during the day.

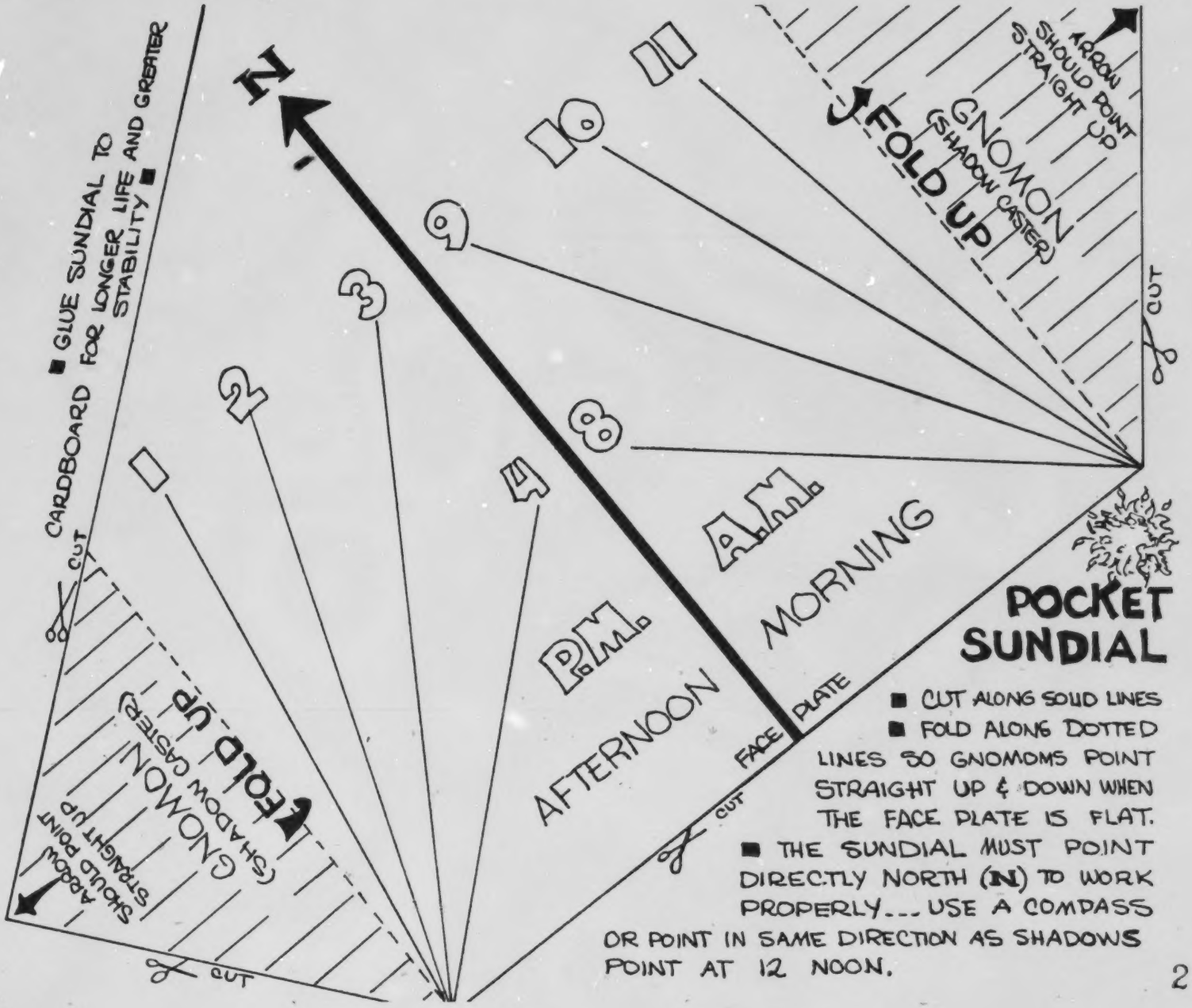
MATERIALS:

1. 21 x 28 cm piece of cardboard
2. glue
3. Pocket Sundial (included)
4. compass (or other method to determine directions)

PRE-LAB: This activity requires observations of the shadow cast by the sun for various times during the day.

When using this device, you may note that the hours are not correct if you are using Daylight Saving Time. Have students figure out why.

PROCEDURE: Follow the instructions written on the "Pocket Sundial". Observe during a class period. MAKE SURE THE GNOMONS ARE PERPENDICULAR TO THE HORIZONTAL.



POCKET SUNDIAL

- CUT ALONG SOLID LINES
- FOLD ALONG DOTTED LINES SO GNOMOMS POINT STRAIGHT UP & DOWN WHEN THE FACE PLATE IS FLAT.
- THE SUNDIAL MUST POINT DIRECTLY NORTH (N) TO WORK PROPERLY... USE A COMPASS OR POINT IN SAME DIRECTION AS SHADOWS POINT AT 12 NOON.

A-3-2

TITLE: Astronomy: Latitude and Altitude of the Celestial Poles

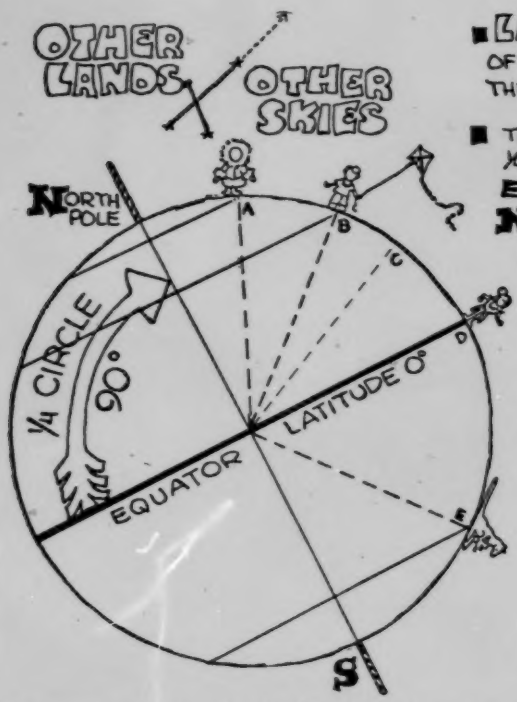
David C. Ulmer
Mitchell High School
Colorado Springs, Colorado

PURPOSE: To demonstrate that latitude and the altitude of the celestial poles are equal for an observer.

MATERIALS:

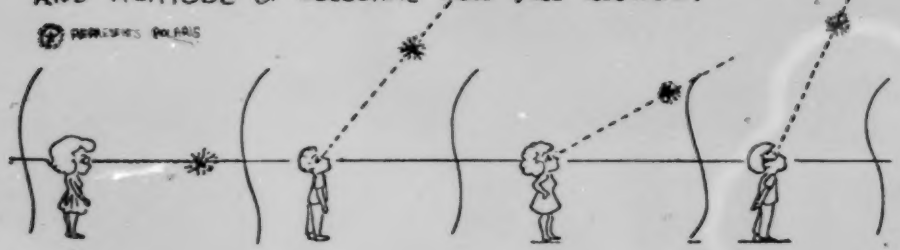
1. protractor
2. this page.

PROCEDURE: Follow procedure on this page.



- LATITUDE IS A MEASURE OF HOW FAR NORTH OR SOUTH OF THE EQUATOR YOU ARE
- THE NORTH POLE IS ¼ CIRCLE (90°) NORTH OF THE EQUATOR, THEREFORE, THE N POLE'S LATITUDE = 90°N
- USE A PROTRACTOR TO MEASURE THE LATITUDE OF THE POINTS AT A·B·C·D·E WRITE THE LATITUDE OF EACH LETTERED POINT NEXT TO THE LETTER.
- SHOW WHERE THE NORTH AND SOUTH SKY POLES (CELESTIAL POLES) ARE LOCATED RELATIVE TO EARTH BY DRAWING A △ WHERE EACH OF THE 2 CELESTIAL POLES IS LOCATED

- THE PICTURES BELOW REPRESENT AN OBSERVER AT 4 DIFFERENT LATITUDES. USE YOUR PROTRACTOR TO MEASURE THE ALTITUDE OF THE CELESTIAL POLE AS SHOWN IN EACH PICTURE. MATCH THE OBSERVER IN EACH PICTURE WITH ONE OF THE 4 LETTERED POINTS ON THE GLOBE. HINT: RECALL HOW LATITUDE AND ALTITUDE OF CELESTIAL POLE ARE RELATED.



TITLE: Astronomy: Exploring Size-Distance Relationships within the Solar System and to the Nearest Star

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Halifax, Virginia 24558

PURPOSE: Use a scale factor to plot the size and distance of the planets and the nearest star (Alpha Centauri) to the Sun in metric units.

MATERIALS:

1. mural paper (approximately .5 meters wide and 5.5 meters long)
2. meter stick
3. scissors
4. construction paper
5. glue

PRE-LAB: Put this chart up prior to beginning work on mural: Activity can be completed in one 55 minute class period.

PLANETS	DIAMETER	AVERAGE DISTANCE FROM THE SUN	DIAMETER OF PLANET ON MURAL 1 mm = 800 km.	DISTANCE FROM PLANET TO SUN ON MURAL 1 mm = 1.2 mil. km
Mercury	4,816 km	57.6 mil. km	6 mm	5 cm
Venus	12,176 km	107.2 mil. km	1 cm 5 mm	9 cm
Earth	12,661 km	146.8 mil. km	1 cm 6 mm	1 dm 3 cm
Mars	6,624 km	225.6 mil. km	1 cm	1 dm 9 cm
Jupiter	138,720 km	772.8 mil. km	1 dm 7 cm 8 mm	6 dm 3 cm
Saturn	114,400 km	1,433.6 mil. km	1 dm 2 cm 7 mm	1 m 1 dm 6 cm
Uranus	47,200 km	2,851.2 mil. km	6 cm 3 mm	2 m 3 dm 8 cm
Neptune	42,800 km	4,468.8 mil. km	5 cm 4 mm	3 m 7 dm 5 cm
Pluto	9,600 km	5,920 mil. km	1 cm 2 mm	4 m 9 dm 8 cm
Alpha Centauri	1,427,000 km	41,000,000,000,000 km	1 m 7 dm 8 cm 6 mm	3400 km

PROCEDURE: Draw a slightly curved line at the left edge of the paper to represent the Sun's rim. Using the chart, measure and draw planets. Cut out planets and glue in correct positions on mural paper, using the distance information on the chart. (Note problem with putting Alpha Centauri on the mural; the distances are so great, that it is impossible!)* You should use different colored paper for each planet since it shows up better. Note: the scales used for diameter and distances are quite different; it is impossible to use the same scale for both distances and distances since the distances are so many times greater than diameters. Be sure to point out this fact to students.

*When students discover that they cannot fit Alpha Centauri on the mural paper, ask them to calculate how much paper they would need based upon their scale factor.

TITLE: Astronomy: Retrograde Motion of Mars

Paul H. Knappenberger
Science Museum of Virginia
Richmond, Virginia 23220

PURPOSE: After completing this activity, the student should be able to describe the path of Mars through the background starfield based on data from May through December 1971.

MATERIALS:

1. pencil
2. star chart(included)
3. table (included)

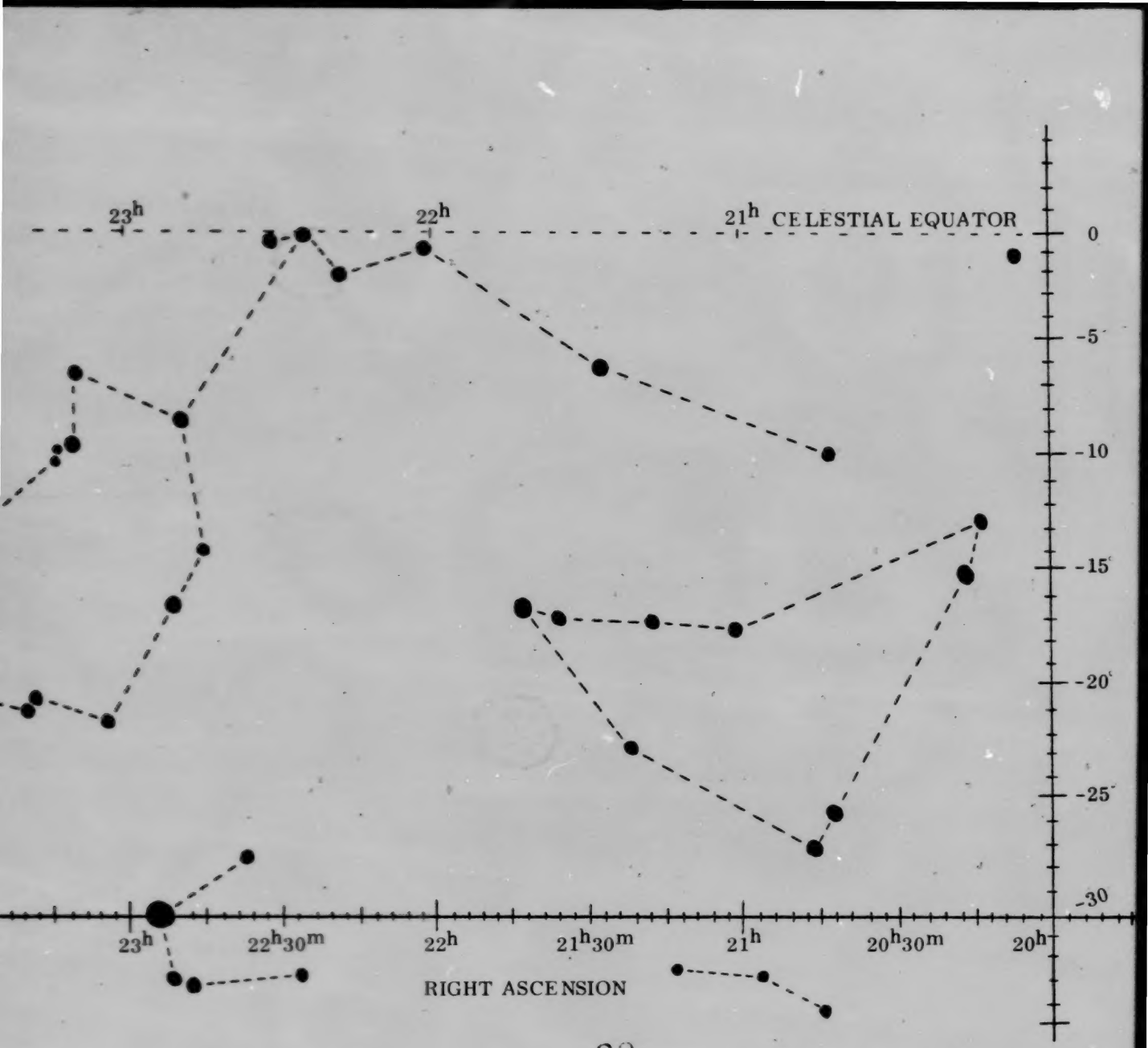
PRE-LAB: This activity can be completed in the classroom in less than one hour.

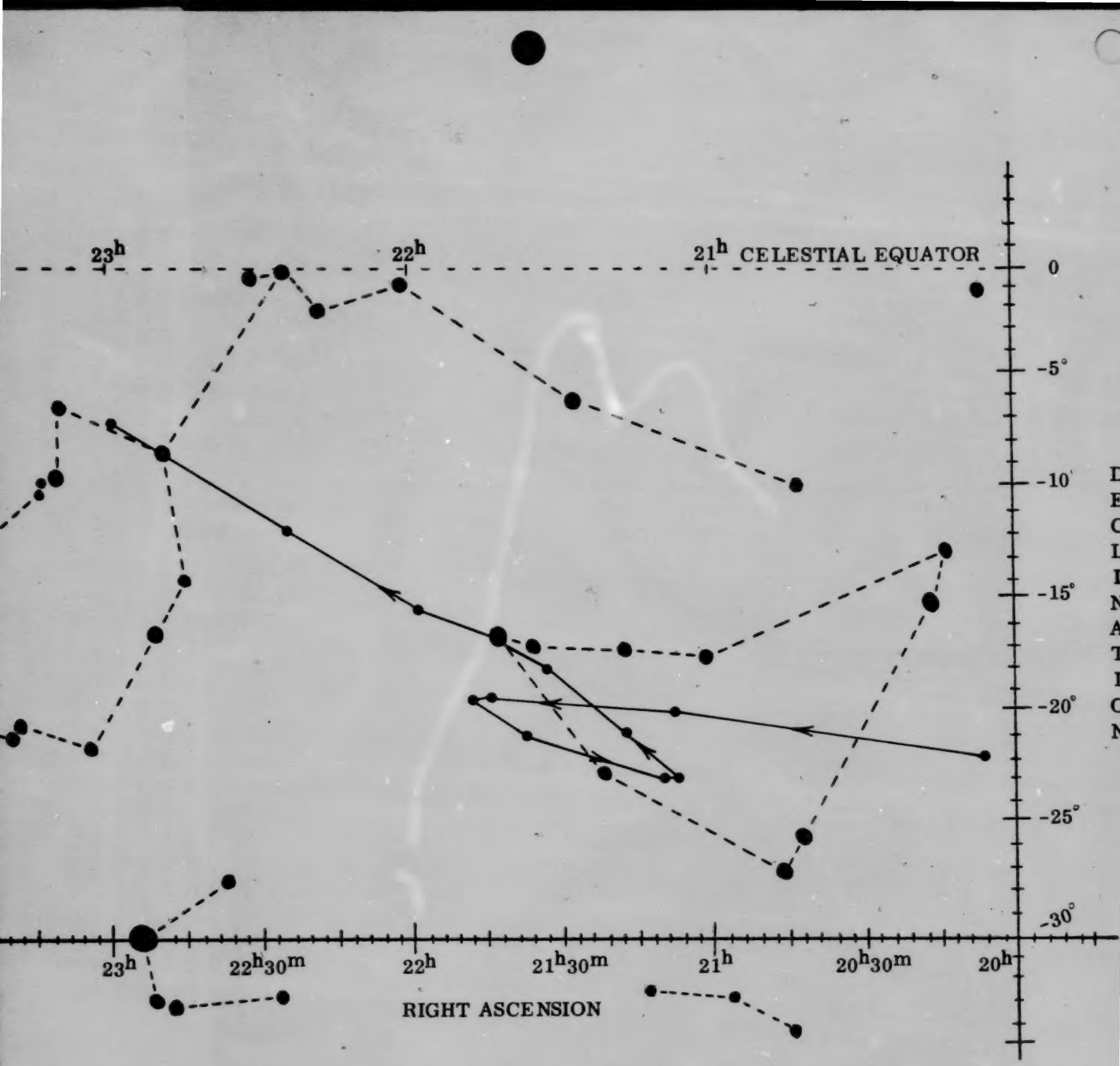
In the early days of astronomy, planets were distinguished from stars by their "wanderings" or apparent motions through the fixed starfield. One puzzling aspect of their motion was the apparent reversal of direction and backward movement (retrograde motion) at certain times of the year. Elaborate models were proposed to explain the retrograde loops made by the planets, and dissatisfaction with the accuracy and complexity of these models eventually led Copernicus to his heliocentric theory of the Solar System.

This activity demonstrates the retrograde loop followed by Mars during 1971.

PROCEDURE: Using the star map, plot the positions of Mars as given in the table. Label each position 1, 2, 3,... and connect the dots. Draw arrows on the path to indicate the direction of travel.

DATE	RIGHT ASCENSION	DECLINATION
1 May 1	$20^h\ 04^m$	-22^o
2 June 1	$21^h\ 05^m$	-20^o
3 July 1	$21^h\ 41^m$	-19^o
4 July 13	$21^h\ 45^m$	-19^o
5 Aug. 1	$21^h\ 36^m$	-21^o
6 Sept. 1	$21^h\ 07^m$	-23^o
7 Sept. 11	$21^h\ 04^m$	-23^o
8 Oct. 1	$21^h\ 15^m$	-21^o
9 Oct. 15	$21^h\ 32^m$	-18^o
10 Nov. 1	$22^h\ 01^m$	-15^o
11 Nov. 15	$22^h\ 28^m$	-11^o
12 Dec. 1	$23^h\ 02^m$	-7^o


23h
22h
21h CELESTIAL EQUATOR
0
-5
-10
-15
-20
-25
-30
23h
22h30m
22h
21h30m
21h
20h30m
20h
RIGHT ASCENSION


23h
22h
21h CELESTIAL EQUATOR
0
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-20°
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22h
21h30m
21h
20h30m
20h
RIGHT ASCENSION

TITLE: Astronomy: A Study of Impact Cratering and Lunar Features

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PURPOSE: Part A: To learn the principles of impact cratering by studying laboratory-produced craters; and Part B: To analyze lunar features from lunar surface photographs to determine their chronological sequence.

MATERIALS:

Part A:

1. sand-filled box (approximately 1 x 1 meter, 15 cm deep) (Sand should be as fine as possible; aquarium sand, for example. You will need from 50-75 kg of sand)
2. dry powdered tempera paint
3. slingshot
4. meter stick
5. millimeter ruler
6. protractor (to set up angle impact measurements)
7. sieve
8. step ladder (to acquire needed height)
9. projectiles (spheres of various mass and densities, e.g. glass, aluminum, plastic, steel, etc. One should be approx. 6 mm in diameter)

Part B:

1. lunar photograph (included)(photograph reproduced from NASA photo number 68-H-540 courtesy of the National Aeronautics and Space Administration).
2. classification scheme (included)
3. atlas of the moon's surface (optional)

PRE-LAB:

1. Part A or Part B can be done separately. Neither the materials nor procedures of either part are necessarily dependent upon the other.
2. For Part A, prepare a smooth, flat surface in the sand-filled box. EXPERIMENT WORKS BETTER IF SAND IS WET. Sprinkle the tempera color onto the surface of the wet sand. Divide the target area into sections so that you can do more than one experiment.

PROCEDURE: (Part A) You may want to choose a few of the following experiments to have students investigate because a long time period is involved to complete all activities. The greater the velocity, the more noticeable the results. Observe the sand patterns, after removing projectile.

After each experiment, sketch a map of the resulting crater to at least 5 crater radii. Describe especially the light-colored sand around the crater. Identify crater cavity, crater rim, and ejecta blanket (material thrown out of the crater at impact) for each experiment.

1. Slingshop experiments (OBSERVE SAFETY MEASURES IN THE USE OF SLINGSHOTS)
   a. Produce a crater using a slingshot to launch a 6 mm projectile fired perpendicular to the target surface.
   b. Produce a crater under identical conditions except the projectile is launched at an angle of 65° from the horizontal target surface.
   c. Produce a crater with the projectile launched at a 40° angle to the horizontal surface.
   d. Produce a crater in which the impact angle is 5° to the horizontal surface.

c. Shoot projectile with slingshot extended approximately 23 cm. (V_1 = 1000 cm/sec.)
d. Shoot projectile with slingshot extended approximately 36 cm. (V_1 = 3000 cm/sec.)

3. Projectiles of different mass dropped from approximately 2 meter height; all vertical impact.
   a. Drop projectiles, one at a time, and study the impact craters.
4. Crater Degradation - Using the slingshot and projectiles of larger and smaller mass, make one large crater with a large projectile, and then:
   a. produce large craters at one crater radius from the first crater;
   b. produce small craters on the rim of the original large crater and; describe changes on the original crater, especially the ejecta blanket.
5. Erosion Caused by Meteoroid Impact
   Prepare a steep ridge in the target surface to stimulate a mountain ridge.
   a. Produce three craters on the ridge, using projectiles of large identica mass. Produce craters for three different angles; 90°, 45°, and 5°. Compare the crater shapes to those in Experiment 1 (Slingshot experiments).
6. Compare all results obtained with available photographs of the lunar surface (including those in Part B) and try to point out craters produced on the moon in ways similar to the experimental craters.

PROCEDURE: (Part B) In Part A, you developed an understanding of how craters are formed. In Part B, you will try to develop a chronology for the occurrence of many lunar features, including craters, which you have just studied.

1. Examine the photograph, which includes a series of numbers.
   a. Paying particular attention to the numbered features, but not excluding unnumbered features, try to group the features into 5 to 10 classes, based on their similarities.
   b. Next, try to determine the probable order of occurrence.
   c. Present your classification scheme to your teacher for class discussion.
2. Features on the moon are usually classified according to the time of formation, or age, thus:
   I. Pre-Mare (structures present before the lavas rose to the surface of the moon);
   II. Mare (major inundation by lava);
   III. Post-Mare (last stages of lava flow);
   IV. Later (any time after post-mare).

Below is a CLASSIFICATION SCHEME FOR LUNAR FEATURES

These are features appearing on the moon (All features are not present in the photograph).

Highlands - rugged, mountainous area of the moon, generally appear bright and heavily cratered. Thought to be the oldest visible lunar feature.

Mountains - as on earth, ranges of peaks which may reach 10,000 - 20,000 feet above the surface. Usually bright and fairly rugged, showing very little erosion or wear.

Isolated Peak: a very high peak on the mare floor. This may have been part of a mountain range, but has survived a flooding by the mare material which now covers all the lower mountains. In such a case, remnants of an entire chain should be seen sticking through the mare material. In other cases isolated peaks are lava cores pushed up by the mare material. These are often associated with wrinkle ridges.

Mare: low-lying expanses of smooth, dark and relatively uncratered material. Often circular and surrounded by circular chains of mountains.

Mare material: the dark, smooth appearing, lava-like material filling the mare basins. Has the appearance of a solidified flood or flow, and is thought to have welled up from the moon's interior.

Impact crater: cavity in moon's surface caused by rapidly moving meteorite. Raised rim, bright ejected material, and smaller secondary craters are characteristic of this common lunar feature.

Central Peak: a single or multiple mountain peak within some of the larger impact craters on the moon. Caused by a rebounding shock wave, it is probably not the remains of the meteorite.

Sunken crater: an old impact crater whose wall has been broken and whose floor has been flooded by dark material. Often only the highest portion of the rim survives. These craters clearly predate the appearance of the mare material, but not the basins.

Wrinkle-ridge: a twisted, ridge-like wrinkle in the mare material, frequently having the appearance of a wave crest frozen in place. These slightly elevated features may be the site from which mare material was extruded.

Rilles: depressed channel-like features, having the general appearance of dried river beds. Often twisted into snake-like patterns (sinuous rilles), these features run for hundreds of miles across the surface of the moon, superimposed on top of almost all other features. They may be the channels from which lava at one time flowed.

Volcanic Crater: a crater formed by internal pressures, usually rimless with little or no (dark) ejected material. Shallow, depressed, dimple-like craters are sometimes found associated with rilles. Contrast these with impact craters.

Dome: a raised, hemispherical projection above the lunar mare. They resemble frozen bubbles of lava material, and are most likely volcanic in origin.

a. Look at the photograph. Using the CLASSIFICATION SCHEME and information above, try to determine the chronology, or order in which the numbered features occurred on the moon.

b. Present your chronological list to your teacher.

3. Using an atlas of the moon or other available lunar photographs, determine the chronology of events on the lunar surface, with the assistance of the CLASSIFICATION SCHEME above.

CONCLUSION:

Part A: Impact cratering patterns vary according to size and speed of projectiles.

Part B: Lunar features were formed in a chronological sequence. To the teacher: The photograph does not show mountain ranges, isolated peaks, central peaks, wrinkle ridges, or volcanic domes. Answers to chronology and identification sequence in the photograph: 4 (highlands), 3 (sunken crater), 1 (Mare material), 5,6 (rilles), 2 (impact crater).

The photograph shows the Crater Prinz, photographed by Orbiter V on August 18, 1967, from an altitude of 83 miles. Crater Prinz lies in a larger mare region. Picture area covers very roughly 40 x 50 miles.

6
3
1
5

TITLE: Astronomy: Measuring Distance Indirectly

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Brenda Hinson
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PURPOSE: To demonstrate the parallax method in determining distance.

PRE-LAB PREPARATION: Teach the students how to read a protractor and review graphing.

TIME: First day - 10 minutes. Second day - class period and finish for homework.

MATERIALS:

1. graph paper
2. protractor
3. football field (or tennis court, basketball court - any athletic playing area with known dimensions).

PROCEDURE: Day 1 - Have each student choose an object on the other side of your classroom. (example: wall clock). With their palm extended an arm's length away, have them sight the object so that it appears just to the right of their palm. Alternately close the right eye and left eye and observe that the object's position appears to be displaced. This phenomenon is known as parallax, the apparent displacement of a distant object due to the change in the observer's point of the view. In this case each eye viewed the object from a slightly different position.

Day 2 - Take the class to the football field. Have a student stand on the 50 yard line at A (See Figure 2). Have students B and C stand on each 0 yard line. With clear tape, tape the protractor to a book. Place the book on the ground so that the straight edge of the protractor is parallel to and over line BC and the 90^{o} mark lies on the 0 yard line. (Each student at B and C does this at his respective end of the field). Line BC is called the baseline and in this case is 300 feet in length.

Student B measures the angle between the baseline and student A, sighting along a ruler on the protractor. (See diagram, Figure 1). Measure the angle to the nearest degree. Student C follows the same procedure.

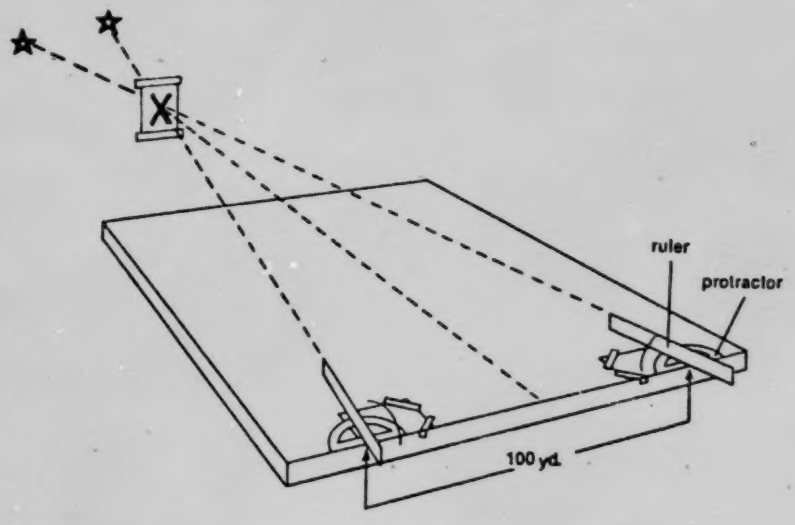

Figure 1

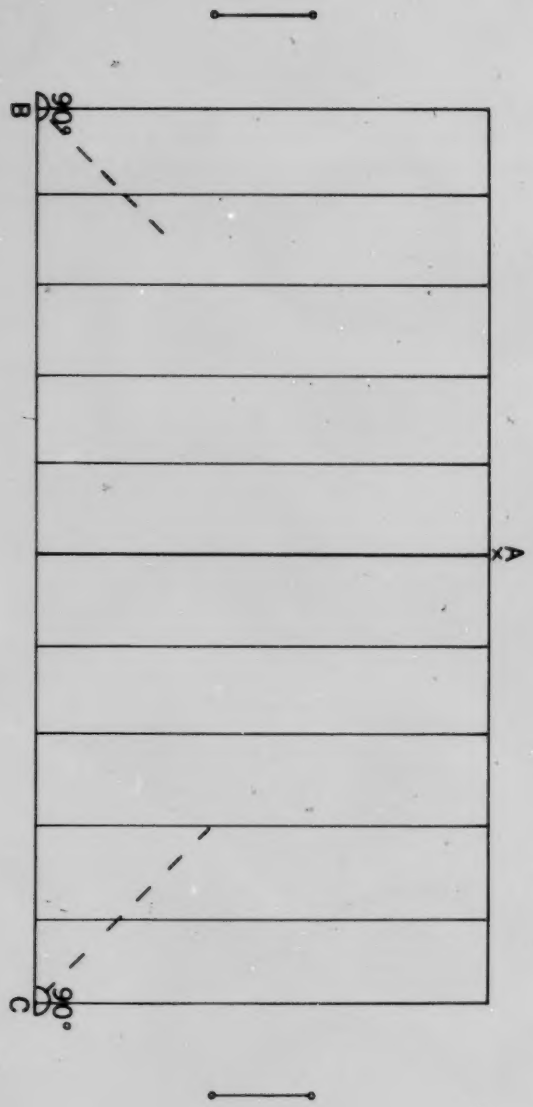

Figure 2

On graph paper, set up your x-axis so that one square = 10 feet. Draw in the angle between student at B to student at A and draw in the angle between student at C to student at A. Connect the lines for your triangle ABC. Measure the distance between A and the baseline by counting the squares. What was the distance across the football field?

Part II - Move student at A to either of the 30 yard lines. Repeat the procedure for above. Put your results on the graph paper in a different color. What was the distance? How does this compare with your first distance?

CONCLUSION: Distances can be determined by using the parallax method whether surveying on earth or sighting on a distant star, if a long enough baseline is avialable to give a detectable difference.

TITLE: Astronomy: Expanding Universe Model

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PURPOSE: After completing this activity, the student should be able to:

1. Demonstrate with a model that the universe appears to expand regardless of the reference point from which it is viewed;
2. Obtain a velocity distance relationship analogous to Hubble's Law.*

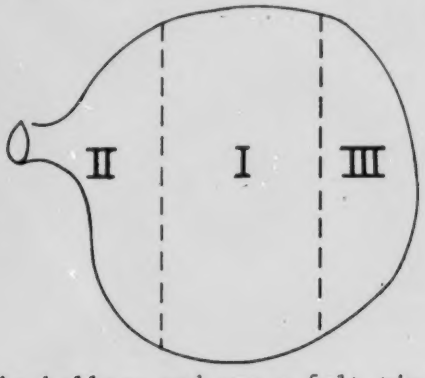
MATERIALS:

1. string (two pieces, each 70 cm long),
2. a medium-sized balloon (spherical shape is best),
3. felt tip marking pen (different color from balloon),
4. ruler,
5. graph paper

PRE-LAB: This activity can be completed in the classroom in one hour. Purpose 1 can be used with all students but purpose 2 should be used with the more advanced students. Be sure that the terms ARC and CHORD are understood.

Nearly all of the galaxies show redshifts in their spectra, which indicate that the Universe is expanding. The farther a galaxy is away from us, the faster it appears to be receding. A simple model involving a balloon can be used to demonstrate this effect and to derive a distance-velocity relationship similar to Hubble's Law for the expansion of the Universe.

PROCEDURE:



1. Inflate the balloon and use a felt tip pen to mark:
   A. our galaxy (MW);
   B. five other galaxies (a, b, c, d and e);
   C. any arbitrary point (p).
   Mark only in region 1 as shown in the diagram, since regions II and III do not expand at a uniform rate.
2. On one piece of string mark off lengths of 30 and 60 cm.
3. Make a centimeter ruler out of a second piece of string.

Hubble's Law explained in most introductory Astronomy textbooks. Reference - An Introduction to Astronomy by Lawrence W. Fredrick and Robert H. Baker.

4. Inflate the "universe" so that its circumference in region I is 30 cm and complete the first part of Table I. Then inflate the "universe" so that the circumference is 60 cm and complete the second part of Table I. Use centimeter ruler and string to measure arc-distances on balloon's surface.

TABLE I

Points	Distance from MW to Points		Distance from P to Points		Points
	Part I ARC When C = 30	Part II ARC When C = 60	Part I ARC When C = 30	Part II ARC When C = 60	
MW to a					p to a
MW to b					p to b
MW to c					p tc c
MW to d					p to d
MW to e					p to e

5. Use figure 1 to convert the Table I ARC distances to chord distance by laying off the arcs with the string and measuring the corresponding chord with a ruler. Enter results in Table II.

TABLE II

Points	Distance from MW to Points		Distance from P to Points	
	Part I CHORD When C = 30	Part II CHORD When C = 60	Part I CHORD When C = 30	Part II CHORD When C = 60
a				
b				
c				
d				
e				

6. Use Table II to calculate:

   a. the velocity of each point by using

      $V = \frac{\Delta D}{T}$ where ΔD = (chord when c = 60) - (chord when c = 30)

      and ΔT = 1 unit of time

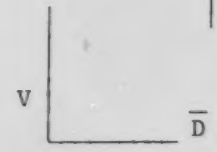
   b. The average distance of each point = $\overline{D}$, where $\overline{D}$ = (Chord when c = 60 + Chord when c = 30)/2

7. Enter the results in Table III.

TABLE III

Point	As seen from MW		As seen from P	
	V	$\overline{D}$	V	$\overline{D}$
a				
b				
c				
d				
e				

8. Use graph paper to plot V vs. $\overline{D}$



and indicate the points that are viewed from MW by enclosing them in a circle (0) that the points that are viewed from P by enclosing them in a triangle (Δ).

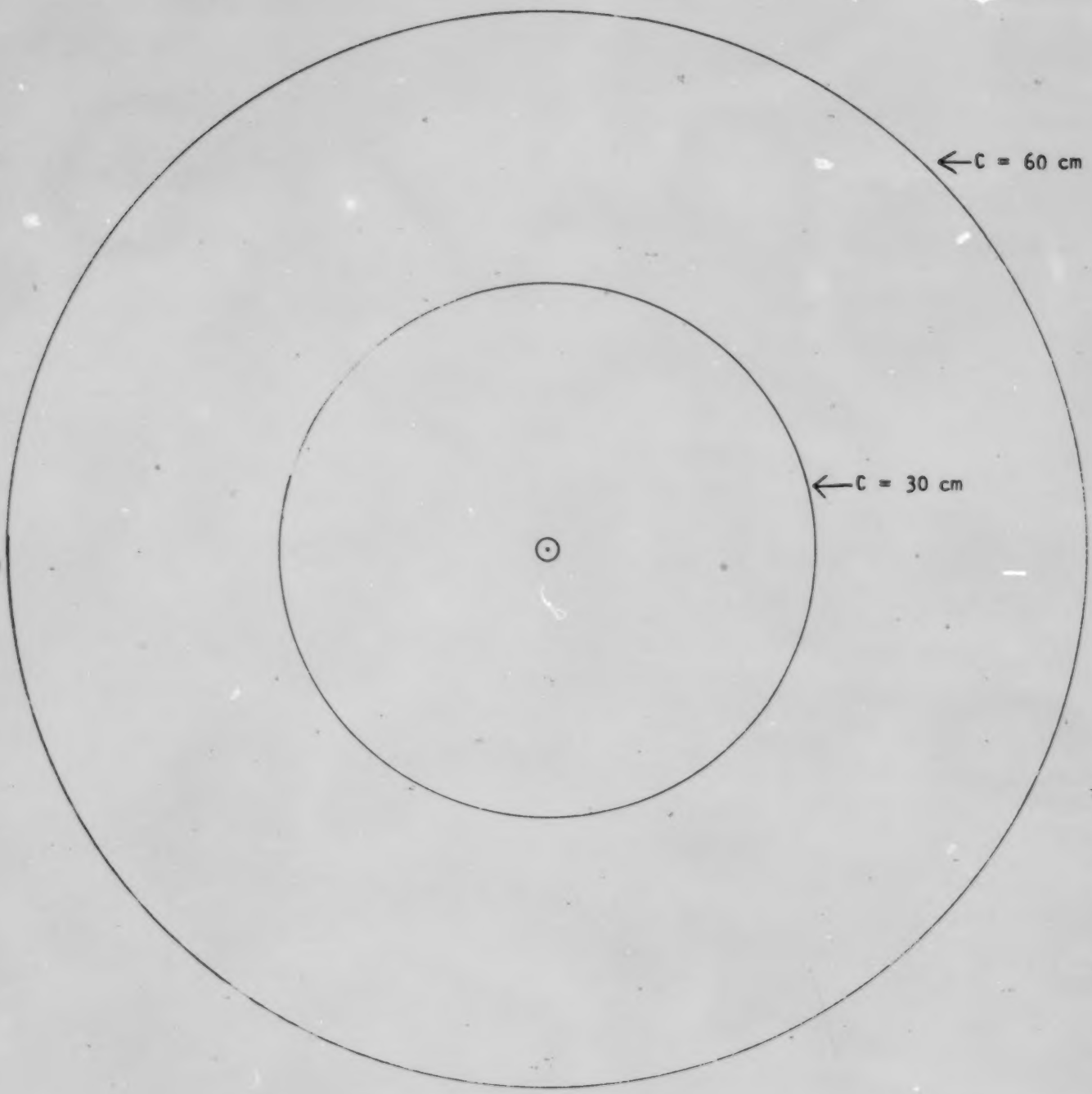


FIGURE 1

Use to convert arc-distance to chord distance for Table II.

SAMPLE RESULTS

TABLE I

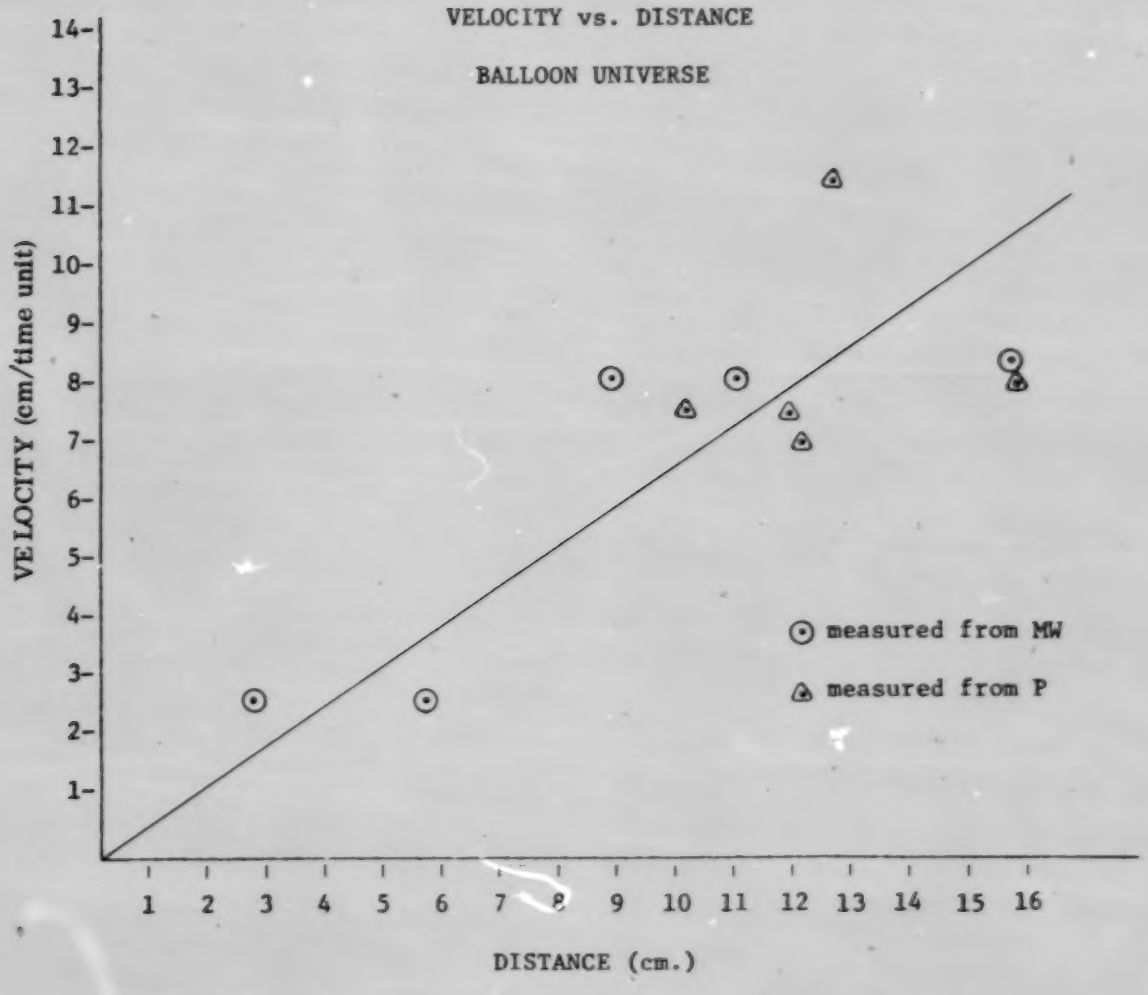
Points	Distance from MW to Points		Distance from P to Points	
	Part I ARC When C = 30	Part II ARC When C = 60	Part I ARC When C = 30	Part II ARC When C = 60
a	1.7 cm	4.3	7.4	16.5
b	8.0	18.0	13.3	30.8
c	5.5	15.0	7.5	25.2
d	12.6	31.3	10.0	18.8
e	4.7	8.0	10.4	18.7
MW	___	___	5.7	12.5

TABLE II

Points	From MW to Points		From P to Points	
	Part I CHORD When C = 30	Part II CHORD When C = 60	Part I CHORD When C = 30	Part II CHORD When C = 60
a	1.6	4.1	6.5	14.2
b	7.1	15.4	11.6	19.9
c	5.1	13.3	6.6	18.7
d	11.4	20.0	8.3	15.8
e	4.4	7.1	8.6	15.7
MW	___	___		

TABLE III

Point	As seen from NW		As seen from P	
	V	$\bar{D}$	V	$\bar{D}$
a	2.5	2.9	7.7	10.4
b	8.3	11.3	8.3	15.8
c	8.2	9.2	12.1	12.7
d	8.6	15.7	7.5	12.1
e	2.7	5.8	7.1	12.2
MW			6.1	8.3



TITLE: Seasons and Constellations Indicator

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PURPOSE:

1. To use the chart to:
   a) Locate the winter and summer stars;
   b) Locate and write the names of the spring and fall stars into blanks;
   c) Locate and list the circumpolar constellations;
   d) Locate and write down the constellation position of the sun;
   e) Locate and write down the sunrise position, noon altitude, sunset position of the sun, and the day length for the beginning day of each season.

MATERIALS:

1. The six chart pages to construct the indicator. (Masters included.)
2. 1-15 cm x 15 cm (approximate) piece of tracing paper per student
3. 1-21.5 cm x 21.5 cm (exact) piece of construction paper per student
4. 1-pair scissors, per student
5. 1-ruler - for each two students
6. glue - one bottle every 8 students
7. 1-round-head brass fastener per star chart
8. 1 strong pin to punch hole through construction paper

PRE-LAB PREPARATION TIME - One period for construction, one period to do laboratory.

1. Assemble materials.
2. Duplicate pages from masters.
3. Cut the 21.5 cm x 21.5 cm pieces of construction paper and the 15 cm x 15 cm pieces of tracing paper to approximate size.
4. Construct a star chart indicator before trying to help student do it.
5. Go through the procedure of the laboratory and fill in all blanks before helping students with it.

PROCEDURE:

A. For constructing the star chart indicator-
Give out the eight pages (six masters + tracing + construction) in the following order, since they will be used in this order to construct the chart.
   1. Tracing sheet overlay
   2. Tracing paper
   3. Seasons and Constellations Indicator
   4. Construction paper (21.5 cm x 21.5 cm)
   5. Remember to rotate the star wheel counter-clockwise
   6. Seasons Information Key
   7. Star wheel
   8. Use of star chart

B. After giving out all materials -
   1. Begin with the tracing sheet overlay and instruct students to cut out the oval along the outside of the heavy line <u>WITHOUT DESTROYING THE CUTOUT PART OR THE REST OF THE SHEET</u>.
   2. Align the tracing paper and glue to the backside of the sheet so that it covers oval window.

3. Put the cutout oval back in place under the tracing paper and trace the information ON THE LINE onto the tracing paper.
4. Cut the top of the page off along the line.
5. Do not fold the bottom yet but put aside and go to the seasons and constellations indicator.
6. Cut out the a) oval window, b) the "Hours of Elapsed Time Indicator" and c) the line marked cut.
7. Fold the two edges back and glue them to the 21.5 x 21.5 cm piece of construction paper. IT IS EXTREMELY IMPORTANT THAT IT BE FOLDED PERFECTLY ALONG THE DASHED LINES. This will form a sort of envelope in which the star wheel will later be placed.
8. Fold the edge of the tracing sheet overlay and glue the folded flap to the back of the construction paper so that the degree of azimuth corresponds perfectly with the window.
9. Fold and glue the "Remember to Rotate" page to the top of the construction paper. It should fold forward to cover the chart.
10. Fold and glue the seasons information key to the bottom of the construction paper. It should fold up to cover the chart.
11. Cut out the star wheel and place it in the "envelope" made by the seasons and constellation indicator and the construction paper (step 7).
12. Fold the tracing sheet overlay over the wheel and adjust the wheel until the star Polaris is directly under the North Celestial Pole (NCP) mark on the tracing sheet.
13. Holding the wheel in place, fold the tracing sheet back, and punch a hole through the wheel and the construction paper and insert the brass fastener through the hole.
14. Cut and glue the "Use of Star Chart" on the back to cover the fastener. The indicator is now completed and ready to use.

Use of the star chart

1. Fold back the tracing sheet overlay and turn the wheel so that December 22 is aligned with 9:00 p.m.
2. Locate the numbered stars which are now in view. The names are shown on the "Bright Stars of Each Season".
3. Turn the wheel so that June 22 aligns with the 9:00 p.m. marker.
4. Locate the summer stars by capital letters which are now in view.
5. Set the wheel on March 21 and list the spring stars that would be visible. Ans. 1, 2, 3, 4, 5, 6, 7, 8, C E F a combination of winter and summer stars.
6. Set the wheel on September 23 and list the autumn stars that would be in view. Ans. 6, 9, A, B, C.
7. To locate the circumpolar constellations place a sharp pencil on the horizon (edge of the oval opening) at the North (0^{o}) position so that as you turn the wheel it will make a circle on the wheel around the circumpolar constellations. List the constellations that fall within the circle. Ans. Ursa Major, Ursa Minor, Cassiopeia, Draco.

Follow the instructions on the seasons information key

A. Locate the sun symbols. - ans.: VE (vernal equinox) - Pisces, SS (summer solstice) - Gemini, AE (autumnal equinox) - Virgo, WS (winter solstice) - Sagittarius.

B. Follow the directions as given in part B. When the VE or AE sun is properly aligned at sunrise about one half of the sun should show above the horizon, it should be due east, and an hour mark should show in the "Hours of Elapsed Time" window.

C. Follow the directions as given. Summer solstice (SS) sun should be at 60° at sunrise and a 1/2 hour marker should appear in the "Hours of Elapsed Time Window." The winter Solstice (WS) sun should be at 120° and a 1/2 hour marker should appear in the Hours of Elapsed Time Window.

Answers

SUN SYMBOL	SUNRISE TIME	DIRECTION AZIMUTH	NOON ALTITUDE	SUNSET TIME	SUNSET DIRECTION	ELAPSED TIME
VE	6:00 a.m.	90° due East	51°	6:00 p.m	270° due West	12 hrs.
SS	4:30 a.m.	60° NE	74.5°	7:30 p.m.	300° NW	15 hrs.
AE	6:00 a.m.	90° E	51°	6:00 p.m.	270° W	12 hrs.
WS	7:30 a.m.	120° SE	27.5"	4:30 p.m.	210° SW	9 hrs.

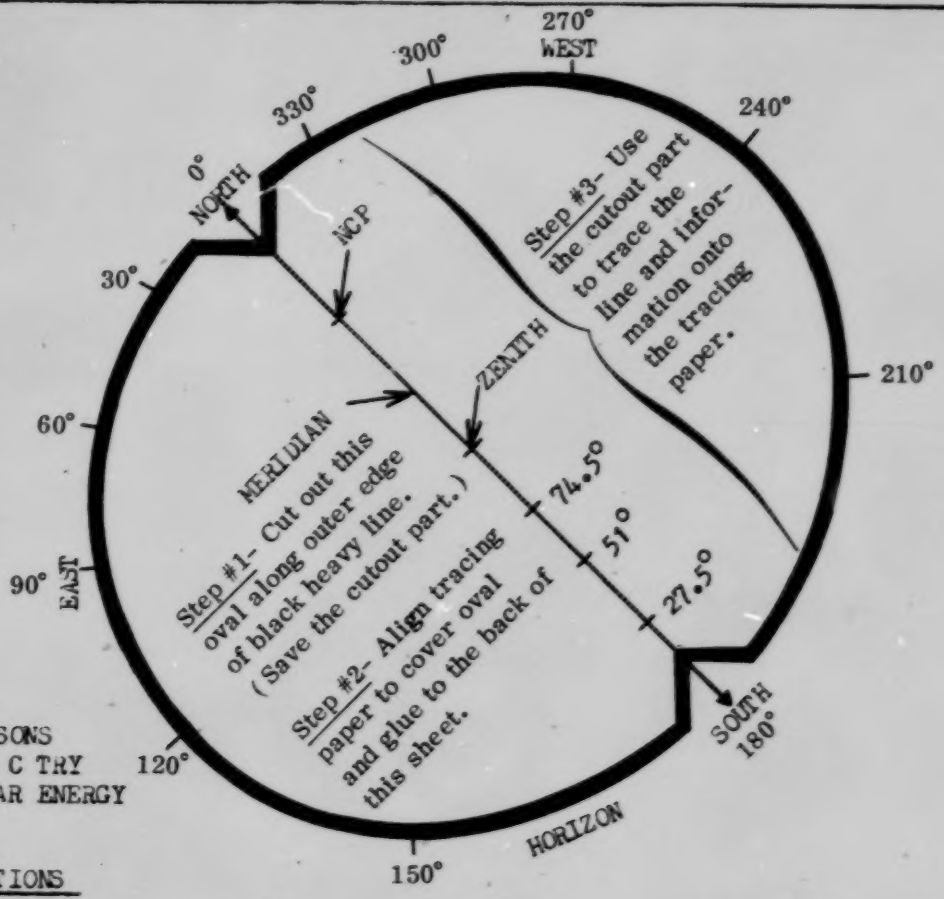
Instructions for use of the star chart in the real sky throughout the year are given on the back of the star chart.

Step #4

CUT ALONG THIS LINE

TRACING SHEET OVERLAY

CUT OUT THIS SPACE



AFTER YOU HAVE COMPLETED THE SEASONS ACTIVITIES A,B, & C TRY ANSWERING THE SOLAR ENERGY QUESTIONS BELOW.

SOLAR ENERGY QUESTIONS

You wish to use a solar energy device. During which season could you collect the greater amount of the sun's energy? At your latitude during which season would you need the most energy? What is the greatest problem with making the dependable use of solar energy? Do you have a solution to this problem?

FOLLOW THESE INSTRUCTIONS CAREFULLY: FOLD FLAP BACK ALONG THIS LINE

THIS TRACING SHEET OVERLAY MUST LINE UP WITH THE HORIZON OF THE FIELD OF VIEW ON THE SEASONS & CONSTELLATIONS INDICATOR DIRECTLY UNDER THE HORIZON ON THIS SHEET.
NOW THIS FLAP MAY BE GLUED TO BACK LEFT SIDE OF INDICATOR

FOLD ALONG LINE

Seasons and Constellations Indicator

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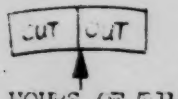
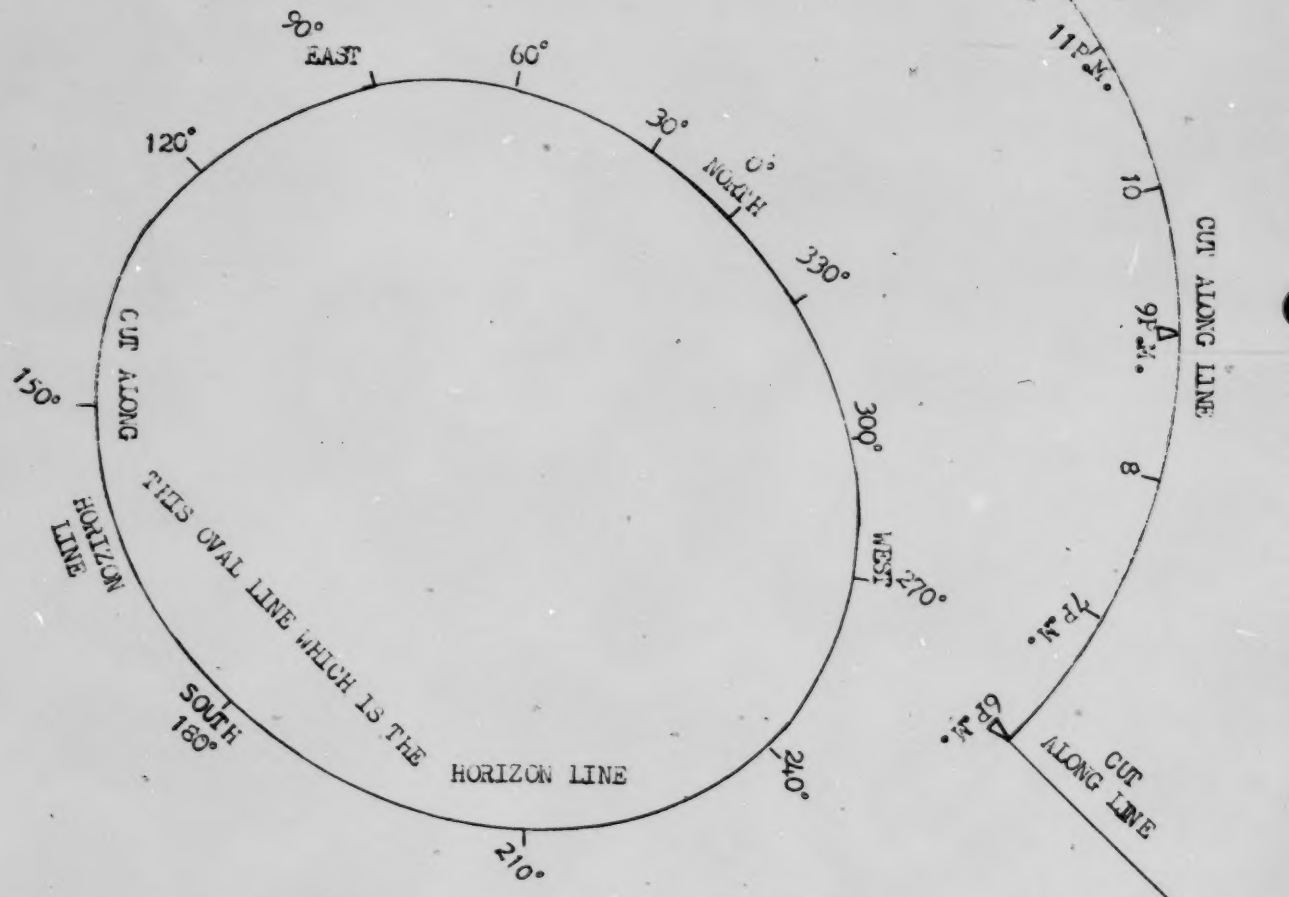


HOURS OF TIME ELAPSED INDICATOR

NAME



HORIZON IS DISTORTED AND THE EAST AND WEST CARDINAL POINTS ARE SHIFTED TOWARD THE NORTH. THIS IS DUE TO THE PROJECTION OF THE THREE DIMENSIONAL SKY WITH APPARENT MOTIONS ABOUT A POLAR AXIS ON TO A FLAT PLANE SURFACE MODEL. AZIMUTH DEGREES ARE APPROXIMATE.

FOLD ALONG LINE

FOLD ALONG LINE AND GLUE FLAP TO LOWER BACK

OF THE SEASONS AND CONSTELLATIONS INDICATOR

SEASONS INFORMATION KEY

SUN SYMBOL	FIRST DATE OF SEASON	N. HEMISPHERE SEASON	LOCATION OF SUN	NOON SUN CROSSES OBSERVER'S ZENITH	ZODIAC CONSTELLATION SUN APPEARS TO BE IN
VE	MARCH 21	SPRING	EQUINOX	AT EQUATOR	
SS	JUNE 22	SUMMER	SOLSTICE	TROPIC OF CANCER	
AE	SEPT. 23	AUTUMN	EQUINOX	AT EQUATOR	
WS	DEC. 22	WINTER	SOLSTICE	TROPIC OF CAPRICORN	

ACTIVITIES (using the SEASONS & CONSTELLATIONS INDICATOR)

A. LOCATE each of the above SUN SYMBOLS on the ecliptic and determine which of the zodiac constellations each appears to be in. COMPLETE the above SEASONS INFORMATION KEY.

B. PLACE the sun marked VE on the eastern horizon (half of the sun should show). PLACE the attached tracing sheet over the field of view. TRACE THE SUN. Now COMPLETE the sunrise information on the DATA TABLE below. USE the HOURS OF ELAPSED TIME INDICATOR and ROTATE the wheel 2 hours. TRACE THE SUN again. REPEAT this rotating and tracing process every 2 hours until sunset (half of the sun showing). Now NOTE the noon altitude of sun on the meridian and COMPLETE noon information on the DATA TABLE. DRAW a curved line connecting the centers of the traced suns. This represents the sun's diurnal (daily) path across the sky on that date. DETERMINE the approximate time of sunset and COMPLETE sunset information on the DATA TABLE. DETERMINE the number of hours of sunlight and COMPLETE the elapsed time indicated information on the DATA TABLE.

C. Follow the instructions in ACTIVITY B with the sun's positions marked SS and WS except trace the sun's positions after each 1 1/2 hours of rotation using the 1/2 hour intervals on ELAPSED TIME INDICATOR.

DATA TABLE

SUN	SUNRISE		NOON	SUNSET		ELAPSED TIME INDICATED
SYMBOL USED	APPROXIMATE STANDARD TIME	AZIMUTH OR DIRECTION	ALTITUDE OF SUN ON MERIDIAN	APPROX. TIME	AZIMUTH OR DIRECTION	FROM SUNRISE TO SUNSET
VE	6:00 a.m.		Degrees		270° West	Hours
SS	4:30 a.m.		Degrees		300° Az.	Hours
AE	6:00 a.m.	90° East	51 Degrees	6 p.m.	270° West	12 Hours
WS	7:30 a.m.		Degrees		240° Az.	Hours

REMEMBER TO ALWAYS ROTATE THE STAR WHEEL COUNTERCLOCKWISE

Bright Stars of Each Season Find the sun position labeled WS. Rotate wheel until December 22 lines up with the 9:00 P.M. time on the indicator. The stars in view are the winter stars as follows:

WINTER STARS

(1) Si'ri us (brightest)
(2) Pro'cy on
(3) Bet'el geuse (red color)
1, 2 & 3 form WINTER TRIANGLE
(4) Ri'gel (blue)
(5) Al deb'a ran
(6) Ca pell'a
(7) Cast'or
(8) Pol'lux (yellow)
(9) Den'eb

Find the sun position labeled SS. Rotate wheel until June 22 lines up with the 9:00 P.M. time on the indicator. The stars in view are the summer stars as follows:

SUMMER STARS

(A) Ve'ga (brightest)
(B) Al tair'
(9) Den'eb (also winter star)
A, B & 9 form SUMMER TRIANGLE
(C) Arc tu'rus (bright yellow)
(D) An ta'res (red color)
(E) Spi'ca
(F) Reg'u lus

NOTE: The spring and autumn stars are combinations of the above. These may be determined by the same process described above, but using the first date of the beginning of each of these perspective seasons. Do you know why? How can you set the wheel another way to show the spring or autumn stars? List the;

SPRING STARS ____, ____, ____, ____, ____, ____, ____, ____, ____, ____, ____

AUTUMN STARS ____, ____, ____, ____, ____.

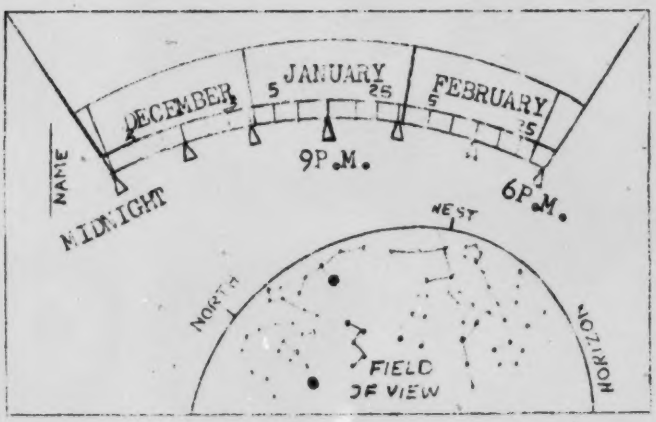
NORTH STAR: Polaris is a star which remains quite stationary above the North Pole. Can you explain how this can be so, as the earth rotates about its axis? Can you explain how this can be so, as the earth revolves about the sun?

CIRCUMPOLAR CONSTELLATIONS: Star patterns which circle Polaris but do not set below the harizon. Name 4 of these. _____, _____, _____, _____.

FOLD ALONG LINE & GLUE THIS FLAP TO TOP BACK OF THE SEASONS & CONSTELLATIONS INDICATOR

DECEMBER
NOVEMBER
JANUARY
OCTOBER
FEBRUARY
SEPTEMBER
MARCH
AUGUST
APRIL
JULY
JUNE
MAY
Scorpius
Sagittarius
Libra
Ophiuchus
Serpens
Hercules
Aquila
Lyra
Capricornus
Corona
Boötes
Draco
Delphinus
Cygnus
Ursa Major
Ursa Minor
Polaris
pointers
Leo
Pegasus
Aquarius
Cassiopeia
Andromeda
Gemini
Auriga
Aries
Pleiades
Cancer
Pisces
Canis Minor
Taurus
Cetus
Orion
Canis Major
ECLIPTIC
VIRGO
AE
VE
SS

USE OF STAR CHART USE THIS SKY INDICATOR THROUGHOUT THE YEAR. TURN THE STAR WHEEL COUNTERCLOCKWISE UNTIL THE DATE OF YOUR VIEW OF THE SKY IS IN LINE WITH THE TIME AT WHICH THE OBSERVATION IS TO BE MADE. STARS IN THE FIELD OF VIEW WILL CORRESPOND WITH THE POSITIONS THEY OCCUPY ABOVE THE HORIZON. HOLD THE INDICATOR UP IN LINE WITH THE DESIRED DIRECTION THAT YOU WISH TO FACE AND OBSERVE.



AT RIGHT IS AN EXAMPLE SETTING.

SET INDICATOR FOR JAN. 15 at 9 P.M.

TERMS USED

ALTITUDE: APPARENT ANGULAR HEIGHT IN DEGREES OF AN OBJECT ABOVE THE HORIZON

AZIMUTH: ANGULAR MEASUREMENT FROM NORTH ALONG THE HORIZON

CARDINAL POINTS: BASIC PRIMARY DIRECTIONS ALONG HORIZON (NORTH, EAST, SOUTH, WEST)

ECLIPTIC: PATH THAT THE SUN APPEARS TO FOLLOW ANNUALLY (yearly)

MERIDIAN: IMAGINARY LINE IN THE SKY WHICH EXTENDS FROM NORTH TO SOUTH AND PASSES THRU ZENITH

ZENITH: POINT IN THE SKY AT 90° ALTITUDE OR DIRECTLY ABOVE THE OBSERVER'S HEAD

ZODIAC: CONSTELLATIONS OR PATTERNS OF STARS WHICH LIE ALONG THE ECLIPTIC

SEASONS OF THE YEAR RESULT FROM 2 BASIC ASTRONOMICAL EFFECTS:

(1) THE CHANGES IN THE LENGTH OF TIME THAT THE SUN IS ABOVE THE HORIZON
(2) THE CHANGES IN THE MAXIMUM ALTITUDE (apparent height) OF THE SUN.

THE ABOVE EFFECTS ARE CAUSED BY THE INCLINATION (tilt) OF THE EARTH'S AXIS BY 23 $\frac{1}{2}^{\circ}$ WITH REPSECT TO THE PLANE OF ITS ORBIT (path around the sun)

CUT ALONG THIS LINE AND GLUE THIS SHEET TO BACK OF INDICATOR CARD

FOLD ALONG LINE AND GLUE FLAP TO LOWER BACK
OF THE SEASONS AND CONSTELLATIONS INDICATOR

SEASONS INFORMATION

SUN SYMBOL	FIRST DATE OF SEASON	N. HEMISPHERE SEASON	LOCATION OF SUN	NOON SUN CROSSES OBSERVER'S ZENITH	ZODIAC CONSTELLATION SUN APPEARS TO BE IN
VE	MARCH 21	SPRING	EQUINOX	AT EQUATOR	PISCES
SS	JUNE 22	SUMMER	SOLSTICE	TROPIC OF CANCER	GEMINI
AE	SEPT. 23	AUTUMN	EQUINOX	AT EQUATOR	VIRGO
WS	DEC. 22	WINTER	SOLSTICE	TROPIC OF CAPRICORN	SAGITTARIUS

ACTIVITIES (using the SEASONS & CONSTELLATIONS INDICATOR)

A. LOCATE each of the above SUN SYMBOLS on the ecliptic and determine which constellation of the zodiac each appears to be in. COMPLETE the above SEASONS INFORMATION KEY.

B. PLACE the sun marked VE on the eastern horizon (half of the sun should show). PLACE the attached tracing sheet over the field of view. TRACE THE SUN. Now COMPLETE the sunrise information on the DATA TABLE below. USE the HOURS OF ELAPSED TIME INDICATOR and ROTATE the wheel 2 hours. TRACE THE SUN again. REPEAT this rotating and tracing process every 2 hours until sunset (half of the sun showing). Now NOTE the noon altitude of sun on the meridian and COMPLETE noon information on the DATA TABLE. DRAW a curved line connecting the centers of the traced sun's positions. This represents the sun's diurnal (daily) path across the sky on that date. DETERMINE the approximate time of sunset and COMPLETE sunset information on the DATA TABLE. DETERMINE the number of hours of sunlight and COMPLETE the elapsed time indicated information on the DATA TABLE.

C. Follow the instructions in ACTIVITY B with the sun's positions marked SS and WS except trace the positions after each 1 1/2 hours of rotation using the 1/2 hour intervals on ELAPSED TIME INDICATOR

DATA TABLE

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SYMBOL USED	APPROXIMATE STANDARD TIME	AZIMUTH OR DIRECTION	ALTITUDE OF SUN ON MERIDIAN	APPROX. TIME	AZIMUTH OR DIRECTION	FROM SUNRISE TO SUNSET
VE	6:00 a.m.	Due E. 90°	51 Degrees	6:00 p.m	270° West	12 Hours
SS	4:30 a.m.	N.E or 60°	74.5 Degrees	7:30 p.m	300° Az.	15 Hours
AE	6:00 a.m.	90° East	51 Degrees	6:00 p.m.	270° West	12 Hours
WS	7:30 a.m.	S.E or 120°	27.5 Degrees	4:30 p.m.	240° Az.	9 Hours

REMEMBER TO ALWAYS ROTATE THE STAR WHEEL COUNTERCLOCKWISE

Bright Stars of Each Season Find the sun position labeled WS. Rotate wheel until December 22 lines up with the 9:00 P.M. time on the indicator. The stars in view are the winter stars as follows:

WINTER STARS

(1) Si'ri us (brightest)
(2) Pro'cy on
(3) Bet'el geuse (red color)
1, 2 & 3 form WINTER TRIANGLE
(4) Ri'gel (blue)
(5) Al deb'a ran
(6) Ca pell'a
(7) Cast'or
(8) Pol'lux (yellow)
(9) Den'eb

Find the sun position labeled SS. Rotate wheel until June 22 lines up with the 9:00 P.M. time on the indicator. The stars in view are the summer stars as follows:

SUMMER STARS

(A) Ve'ga (brightest)
(B) Al tair'
(9) Den'eb (also winter star)
A, B & 9 form SUMMER TRIANGLE
(C) Arc tu'rus (bright yellow)
(D) An ta'res (red color)
(E) Spi'ca
(F) Reg'u lus

NOTE: The spring and autumn stars are combinations of the above. These may be determined by the same process described above, but using the first date of the beginning of each of these perspective seasons. Do you know why? How can you set the wheel another way to show the spring or autumn stars? List the;

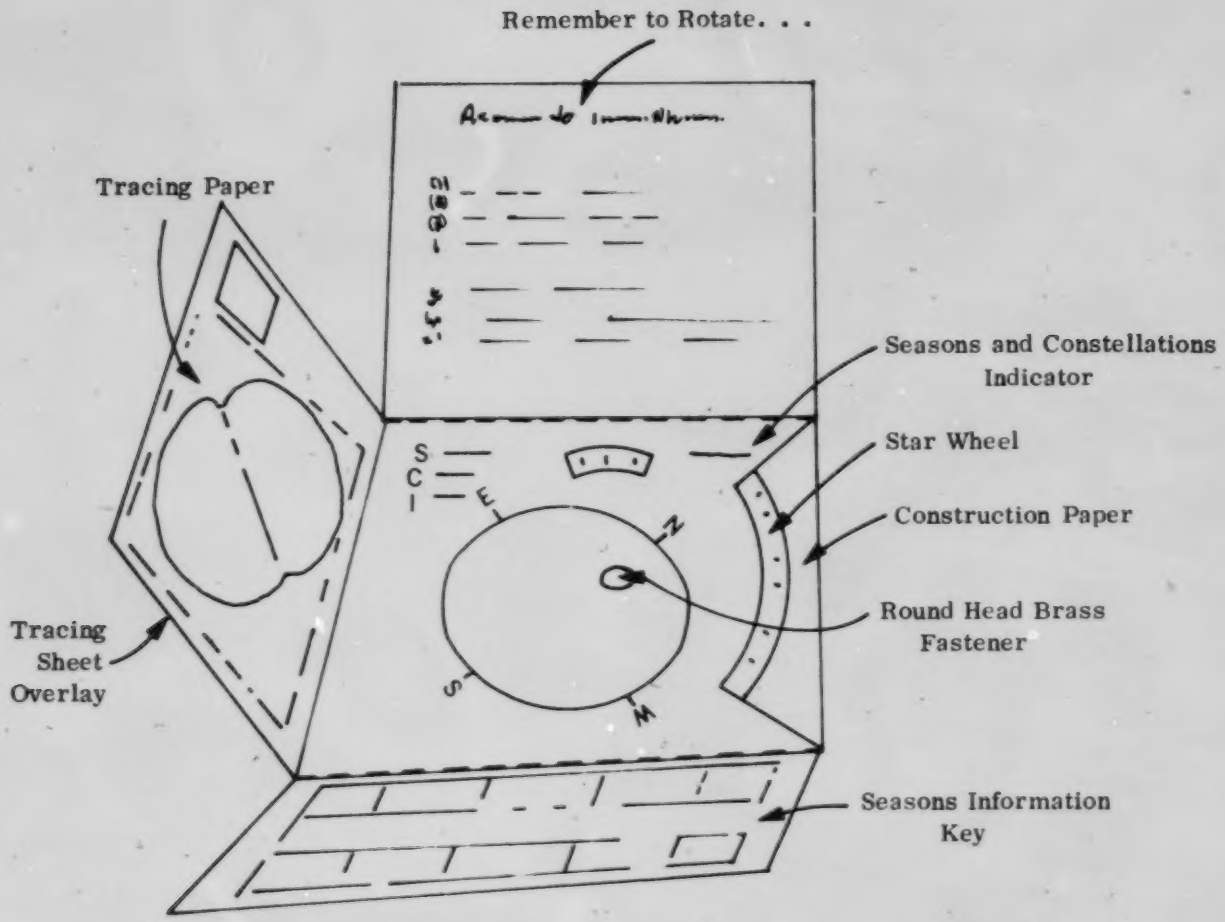
SPRING STARS 1, 2, 3, 4, 5, 6, 7, 8, C, E, F

AUTUMN STARS A, B, C, 6, 9.

NORTH STAR: Polaris is a star which remains quite stationary above the North Pole. Can you explain how this can be so, as the earth rotates about its axis? Can you explain how this can be so, as the earth revolves about the sun?

CIRCUMPOLAR CONSTELLATIONS: Star patterns which circle Polaris but do not set below the harizon. Name 4 of these. Ursa Major, Ursa Minor, Draco, Cassiopeia.

FOLD ALONG LINE & GLUE THIS FLAP TO TOP BACK OF THE SEASONS & CONSTELLATIONS INDICATOR


Remember to Rotate. . .
Tracing Paper
Seasons and Constellations Indicator
Star Wheel
Construction Paper
Round Head Brass Fastener
Tracing Sheet Overlay
Seasons Information Key
S
C
I
E
N
S
M

TITLE: Celestial Crossword Puzzle

Paul H. Knappenberger
Science Museum of Virginia
Richmond, Virginia 23220

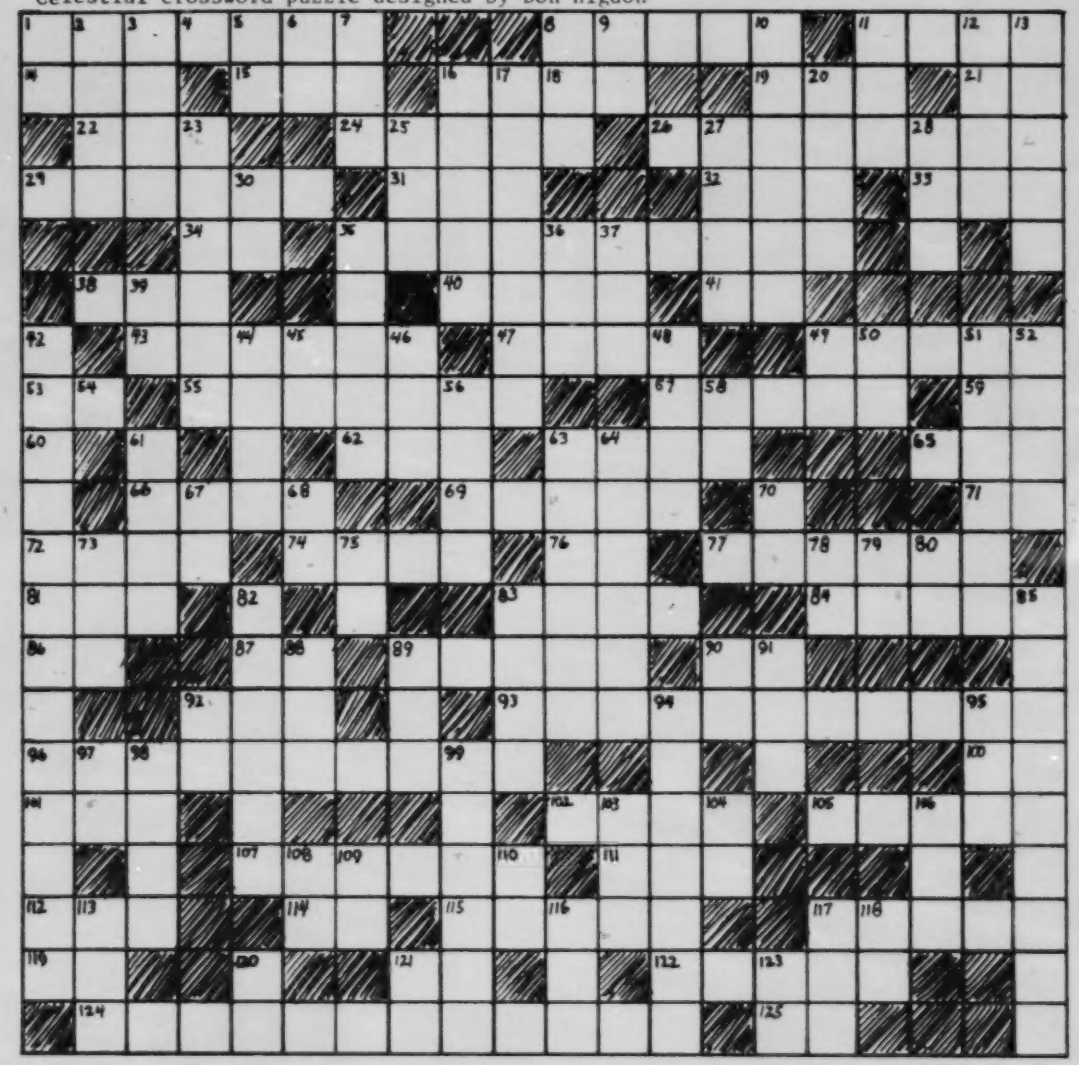
PURPOSE:

1. Key on 50 vocabulary words relating to the Solar System and the stars; the level is intermediate.
2. Provides alternative opportunity for work with element symbols and the periodic table.

MATERIALS:

1. Students will need access to a Periodic Table or listing of the elements.

Celestial crossword puzzle designed by Don Higdon



CELESTIAL CROSSWORD PUZZLE

WORDS ACROSS

1. Early night
8. Helps wake up in the morning
11. How some people have imagined the shape of the Earth
14. Revolution (abbrev.)
15. Mineral spring
16. Prefix meaning "nearest point to"
19. Large ostrich-like bird
21. Symbol for xenon
22. Army soldiers (plural, slang)
24. Group of objects placedon top of each other
26. Object revolving around the Sun beyond the orbit of Mars
29. Very large group of stars
31. Lubricating substance
32. Common beverage
33. Lysurgic Acid (abbrev.)
34. Symbol for tellurium
35. Position in an orbit that is closest to the Sun
38. Greek letter for 'T'
40. Relatively cool area on the Sun's surface
41. Railroad (abbrev.)
43. 7th planet out from the Sun
47. Wide flat areas on the surface of the Moon
49. Small very dense star
53. Symbol for radon
55. 8th planet out from the Sun
57. Form of radiant energy
59. Conjunction
60. Prefix meaning "farthest point from"
62. A single unit
63. Leave out
65. Eaten
66. A Greek word meaning 'love', also the name of an asteroid
69. Path of a revolving object
71. Atomic energy (abbrev.)
72. Large self-illuminated celestial object
74. Natural satellite
76. Lower right (abbrev.)
77. Natural satellite of the Sun
81. Introduced to
83. The red planet
84. Celestial object with a long tail
86. Prefix meaning 'not'
87. International agency (abbrev.)
89. Coldest planet
90. Symbol for barium
92. Nickname for the Sun
93. Of or related to the Earth
96. Increase on speed or change of direction
100. Symbol for cerium
101. Thick black substance
102. Explosion of a star
105. First sign of the Zodiac
107. Sign of the Zodiac symbolized by the bull
111. Biodegrade
112. Spherically shaped object
114. Symbol for manganese
115. One of the stars used in navigation
117. Prefix meaning 'Sun'
119. Symbol for neptunium
121. Symbol for plutonium
122. Planet named for the goddess of love
124. Instrument used to see spectra
125. Symbol for promethium

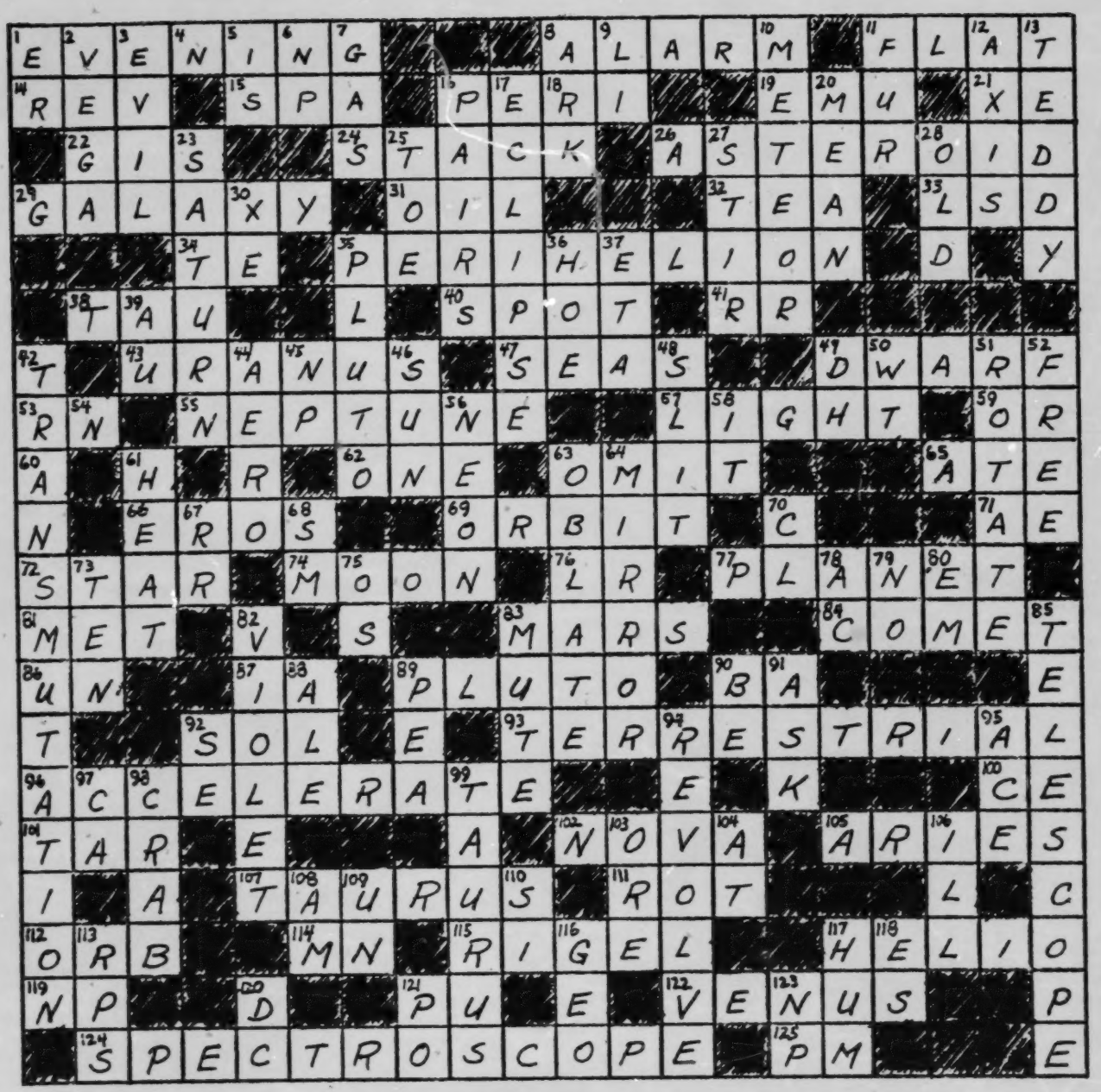
CELESTIAL CROSSWORD PUZZLE

WORDS DOWN

1. Symbol for erbium
2. Brightest star in Lyra
3. Very bad
4. Symbol for nitrogen
5. Form of the verb "to be"
6. Symbol for neptunium
7. One of the states of matter
8. Noah's boat
9. Symbol for lithium
10. Chunk of matter entering the Earth's atmosphere
11. Hair on an animal
12. Center line of rotation
13. Child's name for a bear
16. Groups of two
17. Celestial object casting a shadow on the surface of another celestial object
20. One kind of average
23. Ringed planet
25. Part of the foot
27. Sweep in a circular motion
28. Aged
30. Symbol for xenon
35. Last planet to have been discovered
36. Instrument used in the garden
35. Estimated time of arrival (abbrev.)
39. Symbol for gold
42. Changing H to He by nuclear fusion
44. _ _ _ _ space
45. Symbol for neptunium
46. Source of solar energy
48. Small thin opening
49. _ _ Lawrence (initials; wrote Lady Chatterly's Lover)
50. Weight (abbrev.)
51. To spin on an axis
52. Without charge
54. Symbol for Nitrogen
56. Inert gas
58. Pronoun
61. Thermal energy
63. Shape of the Earth
64. Part of a reflecting telescope
67. Railroad (abbrev.)
68. Symbol for samarium
70. Symbol for chlorine
73. Base number of the metric system
75. Symbol for osmium
78. Alternating current (abbrev.)
79. Symbol for nobelium
80. A printer's measure
82. Color with the shortest wavelength
83. Unable to speak
85. Magnification and light gathering device
88. Alcoholic beverage
89. Small round vegetable
90. Symbol for beryllium
91. To question
92. Symbol for selenium
94. Move in an orbit
95. High card
97. Symbol for calcium
98. Animal symbolized by the constellation Cancer
99. Zodiac sign represented by a bull
103. Rock containing minerals
104. Preposition
106. Sick
108. Form of the verb "to be"
109. Prefix meaning 'not'
110. Symbol for silicon
113. Revolutions per second (abbrev.)
116. Prefix meaning 'Earth'
117. Low quiet noise
118. Symbol for einsteinium
120. Direct current (abbrev.)
121. Symbol for polonium
123. Symbol for neptunium

CELESTIAL CROSSWORD PUZZLE

ANSWER KEY


1 E 2 V 3 E 4 N 5 I 6 N 7 G 8 A 9 L A R 10 M 11 F L 12 A 13 T
14 R E V 15 S P A 16 P 17 E 18 R I 19 E 20 M U 21 X E
22 G I 23 S 24 S 25 T A C K 26 A 27 S T E R 28 O I D
29 G A L A 30 X Y 31 O I L 32 T E A 33 L S D
34 T E 35 P E R I 36 H 37 E L I O N D Y
38 T 39 A U L 40 S P O T 41 R R
42 T 43 U R 44 A 45 N U 46 S 47 S E A 48 S 49 D W A R 50 51 52 F
53 R 54 N 55 N E P T U 56 N E 57 L 58 I G H T 59 O R
60 A 61 H R 62 O N E 63 O 64 M I T 65 A T E
N 66 E 67 R O 68 S 69 O R B I T 70 C 71 A E
72 S 73 T A R 74 M 75 O O N 76 L R 77 P L 78 A 79 N 80 E T
81 M E T 82 V S 83 M A R S 84 C O M E 85 T
86 U N 87 I 88 A 89 P L U T O 90 B 91 A E
T 92 S O L E 93 T E R 94 R E S T R I 95 A L
96 A 97 C 98 C E L E R A 99 T E E K 100 C E
101 T A R E 102 N 103 O V 104 A 105 A R 106 I E S
I A 107 T 108 A 109 U R U 110 S 111 R O T L C
112 O 113 R B 114 M N 115 R I 116 G E L 117 H 118 E L I O
119 N P D 120 P U E 121 V E 122 N 123 U S P
124 S P E C T R O S C O P E 125 P M E

TITLE: Earth Science Bingo Instructions

Sharon Charles
Stonewall Jackson Junior High
Mechanicsville, Virginia 23111

OBJECTIVE: To provide an entertaining review of earth science terms.

MATERIALS:

1. 50 earth science terms
2. "Bingo Boards"
3. small, colored paper squares
4. pencil
5. words and definitions for teacher

PRE-LAB PREPARATION: Teacher must run off one board for each student. Colored paper cut on a paper cutter can be used for chips. (Suitable substitutes may be used). A list of 50 words should be written on the blackboard or written on paper and handed out to each student. This exercise can be completed in one 55 minute class period.

PROCEDURE:

1. Give each student 1 blank "board" and a handful of "chips". List the 50 terms on the board or list them on a handout sheet. The student should randomly fill his board with only 24 of the 50 terms, leaving the middle space free. No two boards should be alike. (Collect handouts for future use.)
2. The teacher should pick a definition from a "hat" and the student should cover the correct corresponding answer on his board.
3. Prizes for each game are encouraged. There should be approximately five winners per class period. A candy bar is great incentive to win!
4. Variations can be played, for example, 4 corners, T, cover the board, or regular Bingo.
5. Hints: At Christmas, a small candy cane may be drawn on the back of one board. Towards the end of class, this candy cane may be used to identify the winner of a door prize. (Teacher should decide the item to be given as a door prize).

B	I	N	G	O
		FREE		

Astronomy Bingo Items

John Kline
James Madison High School
Vienna, Virginia 22180

1. Crater- A depression probably of meteoric or volcanic origin.
2. Maria- Areas of the moon which have few craters and are relatively level.
3. Retrograde motion- The apparent backward motion of the planets viewed from the earth, as they change positions in relation to the fixed stars.
4. Ptolemy- The Greek astronomer who developed a model of earth-centered universe with the planets following circular epicycles.
5. Copernicus- Developed the idea of a sun-centered system with the planets in circular orbits.
6. Tycho Brahe- Made the most accurate measurements of the planets' positions of his day but could not measure parallax so accepted an earth centered universe.
7. Kepler- The assistant of Tycho Brahe who developed the idea of the sun-centered solar system with the planets in elliptical orbits. Developed the three laws of motion.
8. Newton- Developed the laws of celestial mechanics one of which is the law of universal gravitation.
9. Mercury- The planet nearest the Sun.
10. Venus- The brightest object in the sky other than the sun and the moon.
11. Mars- The planet which is about one-half the size of the earth.
12. Jupiter- The largest planet.
13. Saturn- The "ringed" planet.
14. Uranus- The seventh planet from the sun.
15. Neptune- The eighth planet from the sun.
16. Pluto- The most distant confirmed planet.
17. Comet- A mass of rock, ice, dust, and gas revolving around the Sun in a highly eccentric orbit.
18. Luminosity- The total amount of energy radiated into space every second by a star.
19. Apparent magnitude- How bright a star appears to be to an observer on earth.
20. Cepheid variable- A pulsating variable star.
21. Eclipsing variable- A variable star which is really a double star. system in which one star periodically passes in front of the other.
22. Nova- An exploding star.
23. Continuous spectrum- The spectrum which is an emission of all the visible wave lengths of light.
24. Bright line spectrum- The spectrum produced by an element that serves to identify that element specifically.
25. Dark line spectrum- The spectrum produced when light passes through gasses which absorb certain wave lengths.
26. Hertzsprung- Russell Dragram- A graph showing the relationship between luminosity and spectral type (temperature)
27. Red Giant- Very large cool star.
28. White Dwarf- Very small extremely hot stars.
29. Spectroscope- An instrument which separates light energy into its various wavelenghts.
30. Telescope- A light gathering instrument for observing distant objects in space.

31. Corona- Sun's upper atmosphere.
32. Sunspot- Cooler areas on the sun's surface which can be observed from the earth and are the results of magnetic storms.
33. Solar eclipse- The effect on the sun due to the shadow of the moon passing across the surface of the earth.
34. Lunar eclipse- The effect on the moon when the earth's shadow passes across the face of the moon.
35. Milky Way- The name of the galaxy to which the Solar System belongs.
36. Radio telescope- An instrument for concentrating the radio waves from space.
37. Parallax- The angle of apparent shift of a star's position due to the change in position of the observer.
38. Proper motion- The rate at which a star changes its position among the other stars.
39. Radial velocity- Rate at which a star is moving toward or away from an observer.
40. Visual binary- What appears to be one star is actually a double star when viewed through a telescope.
41. Ursa Major- The constellation of which the Big Dipper is a part.
42. Ursa Minor- The constellation of which Polaris is a member.
43. Ecliptic- The apparent path of the Sun among the stars.
44. Zodiac- Constellations located along the ecliptic.
45. Zenith- The point on the celestial hemisphere directly over an observer.
46. Azimuth- The angular distance measured along the horizon from the north point around toward the east.
47. Altitude- The angular distance above the horizon.
48. Perigee- The point in orbit where a satellite is nearest the earth.
49. Apogee- The point in orbit where a stellite is farthest from the earth.
50. Escape velocity- The minimum velocity needed to escape from a celestial object.

GEOLOGY

TITLE: Maps - "Can You Read a State Road Map?"

Sharon Charles
and Richard Scheele
Stonewall Jackson Junior High
Mechanicsville, Virginia 23111

PURPOSE: To help students interpret the legend of a road map.

MATERIALS:
1. worksheet (included)
2. Virginia State Road Map
3. colored pencils
4. blank sheet of paper
5. ruler

PRE-LAB PREPARATION: Obtain Virginia State Road Map and prepare a stencil.

PROCEDURE: Place a blank sheet of paper on top of the worksheet. Trace the area outlined and the roads. Refer to the legend for the correct colors and symbols. All words on the worksheet map will be replaced with colors and/or symbols. Fill in all blanks on worksheet.

Note: Symbols may change as maps are revised.

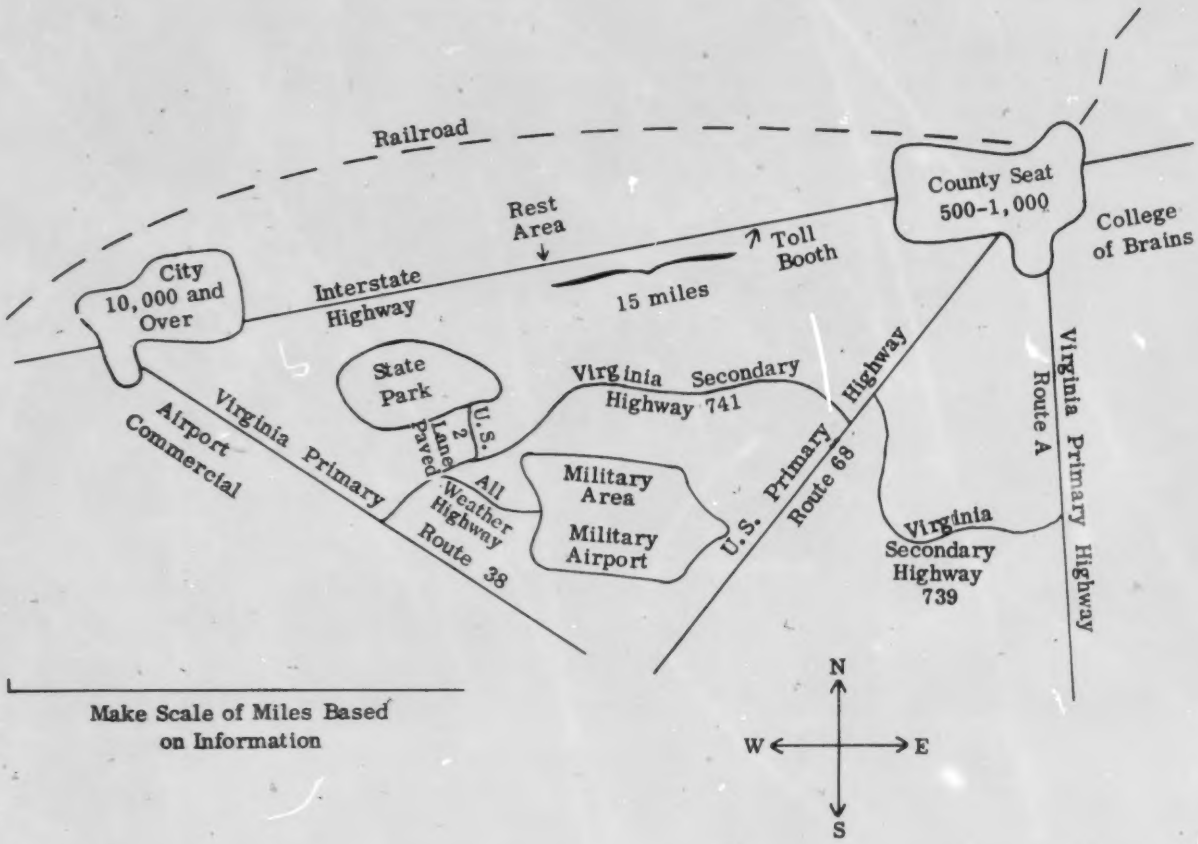
WORKSHEET

Can You Read a State Road Map?

A map has a great story to tell but only when you can understand the _____. It is located in the upper right corner. The title of this map is _____.

Using the information given, redraw the map below using the proper symbols and colors instead of the written names. Use rulers and colored pencils when needed.

It is 45 miles between the county seat and city.



What is your scale of miles? 1 in. = _____ miles.

The military base is (south, southwest, or north) of the county seat?

Is this map current? _____. If it isn't, what year was it made? _____.

TITLE: Maps Give the Picture

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PURPOSE: This is a descriptive activity based on map reading. The purpose is to enable students to become sufficiently skilled at map interpretation so that they can develop a detailed picture of the physical environment of a specific site from maps without having seen the area.

MATERIALS: Maps of as many different kinds as can be assembled for the area to be studied. A list of maps and map sources is included at the end of this activity.

1. Essential maps:
   - One for each group of students
     - U.S.G.S. topographic quadrangle (7 ½ or 15 min. series)
     - U.S.G.S. topographic map 1:250,000-scale series
     - Road map, either of Virginia or of a somewhat larger area
   - One for classroom display
     - Virginia geologic map
     - Physiographic provinces of the United States
2. Other maps depending on availability:
   - One each for classroom display
     - Soil
     - Climate
     - Weather
     - Land Use
     - Mineral Deposit
     - Tectonic (faults)
     - Surface Materials
     - Special maps on slide prone zones, ground water, etc.
3. Supplementary Materials for display:
   - Large scale aerial photographs
   - ERTS - Landsat Imagery
4. Questionnaires for recording information from maps

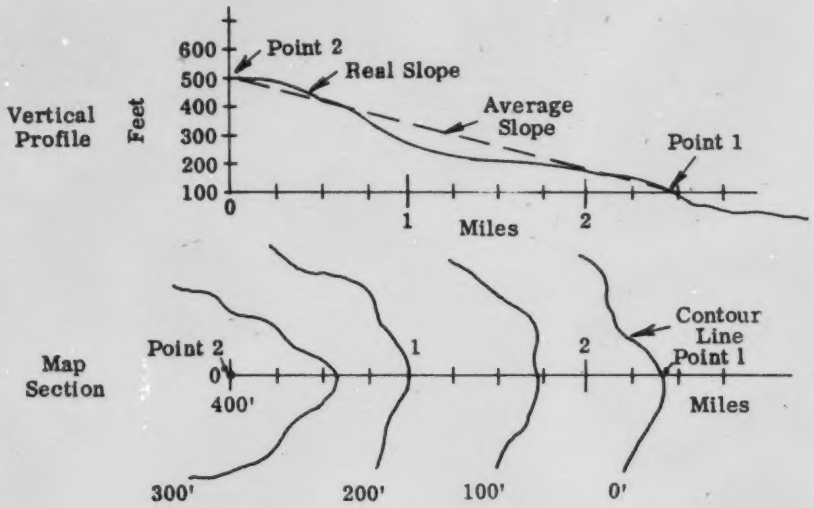
PRE-LAB PREPARATION:

Time - This exercise will take two or more periods depending on the number and variety of maps available and on whether or not it is repeated for an unfamiliar area.

Any site may be chosen. If time permits, the exercise should be done first for a location with which the student is familiar, his home, school, a nearby park. It should be repeated for a site in an unfamiliar locality with different characteristics. The exercise, by concentrating first on an area with which the student is familiar, creates an interest in maps which contributes to mastering skills of map interpretation.

Assemble as wide a variety of maps as possible. Students may be asked to bring in their own road maps. Each group (preferable two, no more than four students) should have its own topographic quadrangle, 1:250,000 topographic map, and road map. Other maps and photographs should be posted around the room where they can be used by two or three students at a time. Group the maps posted by general subject; geology and mineral deposits, various climate maps, etc. Caution the students not to mark the maps as they have to be used by several classes.

Determination of Slope



Distance = 2.5 Miles
Elevation = 500'-100' = 400'
Average Slope (Feet/Mile)
= Elevation/Distance
= 400'/2.5 Miles
Average Slope = 160'/Mile

To measure an average slope between two points, first the horizontal distance must be measured according to the map scale; second, the elevation difference between the two points must be calculated. Using the given equation, the slope in feet per mile can be determined.

feet per mile can be converted to % by $\frac{\text{difference in elevation}}{5280}$

Questions are given below for essential maps. Develop appropriate questions for other maps you are able to obtain and for photographs.

PROCEDURE:

1. Select site to be studied.
2. Study the maps and record information on the following questionnaire.
3. Based on this information, write a narrative description of the site with subheadings related to the various maps: location, topography, geology, etc.

QUESTIONNAIRE:

A. Road Map
   1. On the road map, find as nearly as possible the location of the site you chose (home, school, park, quarry, etc.).
   2. Describe the location of this site by giving directions (north, southwest, etc.) and distances from major roads, political divisions (counties, towns, other states), major streams or other bodies of water. Use scale to estimate distances.

B. Topographic Quadrangle
   1. Find the location of your site on the topographic quadrangle.
   2. Give the following information about your site:
      a) latitide and longitude in degrees, minutes, and seconds
      b) elevation -
         Is this one of the higher, lower, or average elevations on the quadrangle?

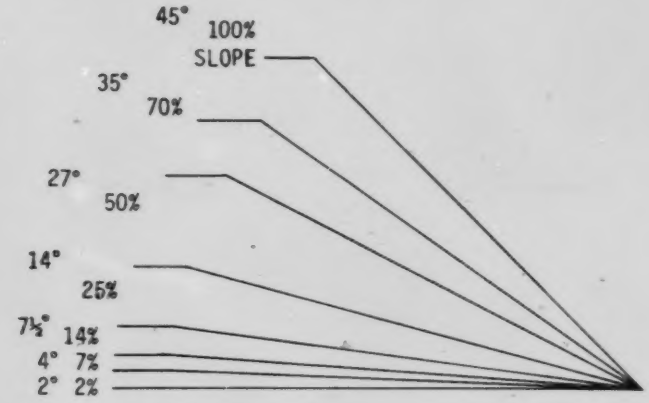
How does this compare in elevation with some well-known landmark in the quadrangle?

c) description of topographic location (steep north-facing slope, level valley bottom, gentle westward slope).

d) description of general topography of the area based on the following classification:

Slope	
0-2%	almost level
2-7%	undulating
7-14%	rolling
14-25%	hilly
25% +	steep

NORMAL ANGLE OF REPOSE [1]
ABOUT 35° = 70% SLOPE



2% = 2°
7% = 4°
14% = 7½°
25% = 14°
50% = 27°
70% = 35°

e) describe the drainage of the area (drainage pattern, local streams at or near site, major streams, gradient, shape of valleys).

f) general location of roads (valley, ridge top, cutting across hills and valleys, winding around).

C. Regional Topographic Map
1. Find the location of your topographic quadrangle on the regional topographic map.
2. Describe the location (central, northeastern corner, etc.)
3. Is the topography of your quadrangle typical of that of the region?
4. List similarities and differences.
5. Does your topographic quadrangle form part of the watershed of a major river that appears on the regional map? If so, which?

D. Geologic Map
1. What geologic age or ages are the rocks near your site?
2. What kinds of rocks are they? (see key on geologic map)
3. Determine whether they are generally horizontal or are faulted and folded. How do you know this? Are any major faults shown?
4. From your knowledge of permeability, would you expect these rocks to be good aquifers?
5. Are any mineral deposits shown in the area of your topographic quadrangle? If so, what kinds?
6. Would you expect to find fossils in these rocks? Why?

E. Physiographic Provinces
1. In what physiographic province is your site located?

2. What have you discovered in your study of the topographic and geologic maps that characterizes the physiographic province?
3. Where are the boundaries of the province in relation to your topographic quadrangle and your regional topographic map?

F., G., etc. - appropriate questions for other maps and photographs.

CONCLUSION: Since this an exercise in map use, no conclusions are to be drawn. The resutls should present in a few paragraphs a rather clear description of the natural physical setting of the site chosen.

From the maps, without having seen the area, what could you tell about possible uses of the land?

EXTENSION: Better students can be encouraged to interpret some of their observations. For example: if the site is on a steep north facing slope, what are the mini-climatic effects apt to be--or what soil and water related problems might be expected on steep slopes or on flood plains?

Sources of Maps:

Eastern Region Map Distribution
U. S. Geological Survey
1200 South Eads Street
Arlington, Virginia 22202

A catalogue of published maps of Virginia can be obtained free of charge by writing to the above address. This lists topographic maps, state maps, county maps, special maps (Appalachian Region, Washington and vicinity, etc.) national park and monument maps, National Atlas thematic maps. It also lists commercial map dealers in Virginia and reference libraries where maps are on file. The catalog includes order forms and information on prices.

National Cartographic Information Center
U. S. Geologic Survey
507 National Center
Reston, Virginia 22092

A "Catalog of Map Data" can be obtained free of charge by writing to the above address. They also will supply, free of charge, "Virginia Index to Topographic and other Map Coverage" and Geologic Map Index of Virginia "Geologic and Water-Supply Reports and Maps of Virginia, Map 1974", a sheet of "Selected References on Virginia Geology", and National Atlas Separate Sales Editions order forms. If you are not familiar with their popular publications, ask for the booklets "Topographic Maps" and "Popular Publication of the U.S. Geological Survey".

Virginia Department of Mineral Resources
P.O. Box 3667
Charlottesville, Virginia 22903

A free list of publications on rocks, minerals, and topographic and geologic maps is available on request.

Check with your County Governments for soil maps, parkland maps, land use maps, etc. What is available depends on the county. Some have excellent aerial photographs.

U.S.G.S. National Atlas Separates particularly recommended for this exercise are:

Climate # 94 and 95 Monthly Sunshine
#97 Annual Sunshine, Evaporation, and Solar Radiation
#106 Monthly Average Temperature
#110 Monthly Minimum Temperature

Water #117 Surface Water

[1] These data from "Know Your Home Environment", Fairfax County Public Schools, Department of Instructional Services, Division of Curriculum Services, 1974.

TITLE: Connecting Contours-- A Surveying Exercise

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PURPOSE: To provide practical experience in surveying, as well as to help the student realize the concept and significance of contour lines and mapping. While models and charts in class provide an avenue for understanding contouring, the actual mapping experience is an excellent method for developing a more concrete experience with the concept of contouring.

MATERIALS:

1. 1-1.0 meter 4 cm x 4 cm Jacob's Staff (See illustration page G-3-3)
2. 1-2.0 meter 4 cm x 4 cm Jacob's Staff (See illustration page G-3-3)
3. 1-40 cm x 20 cm wooden triangle; 1.5 cm thick
4. 1-eye screw
5. 3-small nails
6. 1-50 gram fishing weight or equivalent
7. 1-1 meter piece of string
8. 1-25 meter measuring tape or equivalent
9. 6 students

PRE-LAB PREPARATION: Students must be able to use contour mapping symbols and draw a contour map. Students should not be expected to accomplish this exercise without considerable preparation as to the nature and procedure of surveying and contouring. This activity requires the complete cooperation of the student group members. Each individual must understand his duties.

The teacher should select a study area near the school showing at least 1 meter of surface relief. A man-made drainage ditch or bank will suffice in flat area. A 25 meter baseline must be laid out along with a corresponding 25 meter line 90° to the baseline. A grid can be constructed at "X" meter intervals with the intervals being varied to the nature of the terrain. Students will measure relief variations at selected points along this grid for their contour mapping exercise. Flour or lime can be used to spot the intervals along the base lines. The origin of the grid lines is the zero point at which the transit will operate throughout the exercise.

This activity takes 2 55 minute class periods.

PROCEDURE:

1. Assemble the surveying transit as follows:*
   a. The 1.0 meter staff is the vertical support for the wooden sighting triangle which is nailed to the staff. (see illustration)
   b. The eye screw is the sight with a small nail as the sight piece at the other end of the triangle.
   c. Put a nail at the top and bottom center of the triangle's side.
   d. Tie a string with weight to the upper nail. When the string just touches the lower nail, the transit is vertical. Also, the string should not be touching the triangle's side.
   e. Paint the 2.0 meter staff in .25 meter alternating red and white bands. A red band should be placed to allow the transit to be sighted at its upper margin when the relief difference is zero. (see illustration)

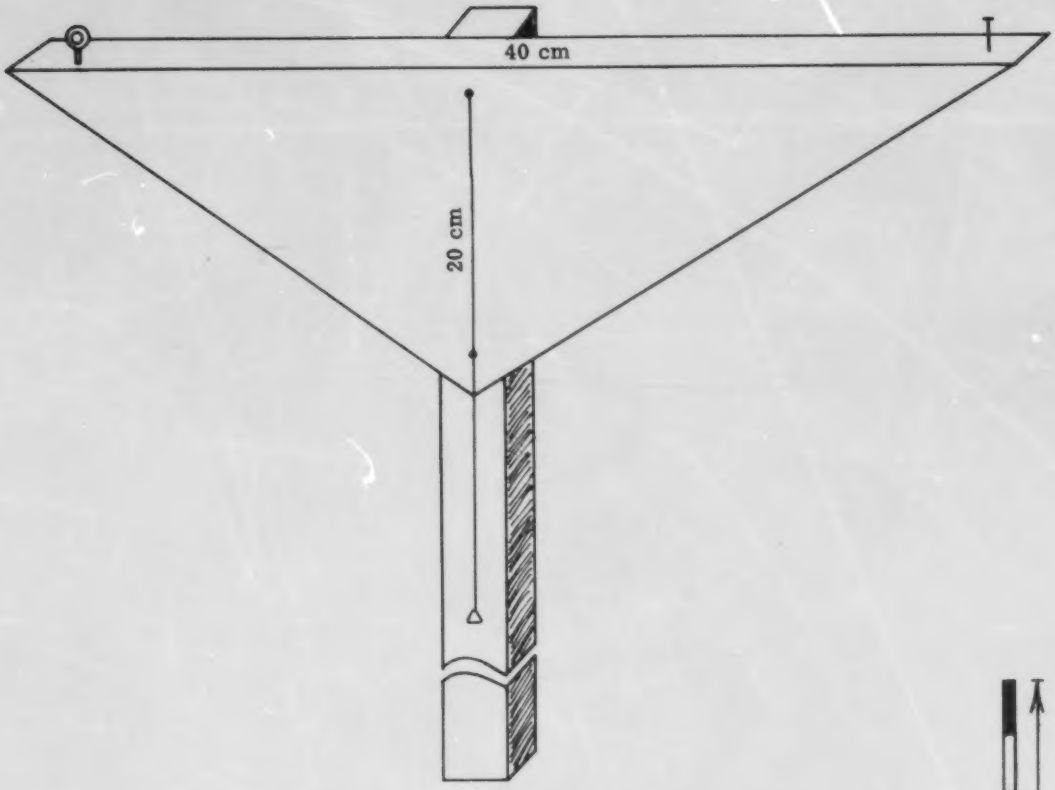
* If possible involve the shop teacher in the construction of the materials for this exercise.

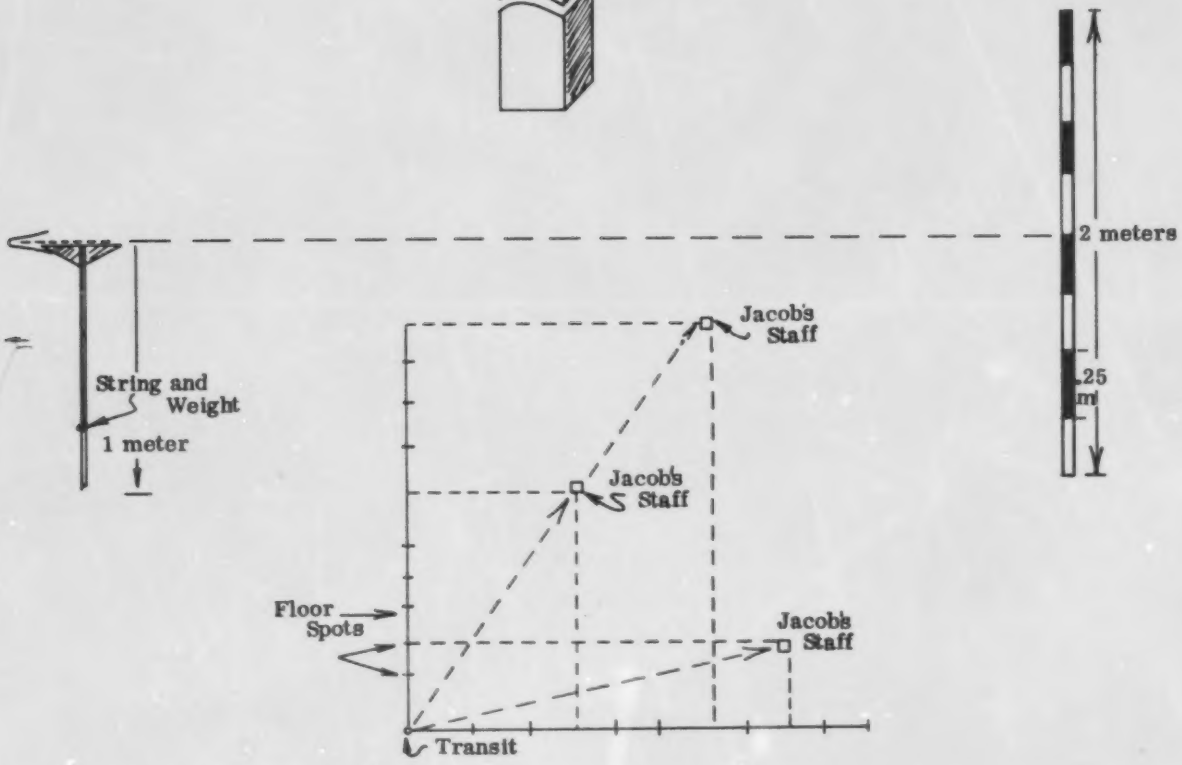
2. The transit is held vertically, and a student sights through the eye screw toward the nail to the 2.0 meter staff or "Jacob's Staff."

One student should hold the Jacob's Staff vertical for sighting at the grid point. Two students are needed to work along each base line to sight the correct placement of the Jacob's Staff. One student each is needed to operate the transit, and Jacob's Staff, with one to keep the equipment vertical, and another to record the readings.

3. The Jacob's Staff operator should move his hand up or down to match the point at which the transit operator sights from his vantage point on the Jacob's Staff. The recorder must mark this reading on the grid. The number of bands are counted along with partial units. Note that the one meter mark on the Jacob's Staff corresponds with the height of the transit. This point is zero with upper bands being counted as negative and lower bands positive with respect to the transit. Readings should be recorded in this manner.
4. The Jacob's Staff operator moves to grid points designated for sighting. After the grid measurements are completed, contours can be drawn to fit the data points. The resulting map can be used to answer questions on drainage or slope etc.

CONCLUSION: Completion of this lengthy exercise should give the student a finished product illustrating contouring and surveying for a real situation. Properly executed this activity should be an important aid in visualizing more complex terrain on maps.


40 cm
20 cm


2 meters
.25 m
String and Weight
1 meter
Jacob's Staff
Jacob's Staff
Floor Spots
Jacob's Staff
Transit

TITLE: Shrink-Swell Properties of Clay[1]

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PURPOSE: This activity is designed to illustrate the effects of wetting and drying on different clay materials.

MATERIALS:

1. Clay minerals (montmorillonite, kaolinite, and any others available-- montmorillonite is most important)
2. Samples of clays brought in by students - site where samples were collected should be noted for each. It is better if they are collected from different areas and the variety of colors is great.
3. Small, low plastic trays (about 10 cm x 10 cm) or saucers
4. Water
5. Dropper

PRE-LAB PREPARATION: The part of this activity begun with dry clay can best be done in groups of not over 6 students. The part begun with wet clay should be a class activity and only one set is needed for the class. It may be possible for several classes to use the same set of trays as long as no apparent drying has taken place before the class examines the trays the first time.

Part I - Trays for Part 1 can be set up ahead of time or students may pick up the trays and clay themselves. Caution them to identify the samples as to type of clay or location of source. Be sure clay is dry and finely powdered.

Part II - Mix enough water with each type of clay material to form a smooth pasty substance. Pour this into trays so that the depth is about .5 cm. Label the trays for identification with either type of clay or source.

PROCEDURE: Part I - Dry clay

1. Place 1 tablespoon of each kind of dry clay in a separate tray, being sure to note the kind or source of the clay.
2. Observe and describe each tray of dry clay.
3. Without moving the trays, very slowly add water to each. Do not let water form splashes or channels in the clay.
4. Describe any differences you observe (color, space-- does it seem to increase or decrease in size?)

Part II - Wet clay

1. Observe and describe each tray of "mud".
   (Trays will be put aside where they can dry for several days.)
2. Each day when you come into class, make observations on each tray of clay noting changes during drying. Note pattern and width of cracks. Note color. Are there any other apparent changes?
3. When drying is complete, measure the widths of the cracks in the different materials.

CONCLUSION: Discuss the effects of wetting and drying on the different materials. How would these characteristics be significant in terms of man's use of land? Consider particularly the significance in terms of construction. How do the effects you have observed resemble

permafrost or playa lakes?

Expected outcome - Part I - What happens depends on the clay-- some will swell appreciably, some will change colors, etc.

EXTENSION: If students have studied plate tectonics, discuss the triple junction, 3 armed crack pattern of the clays in comparison with the similar patterns formed by plate boundaries. Pictures of mud cracks and of cracks in cooling lava can be used to illustrate this characteristic.

[1]Adapted from "Focus on Fairfax County", Fairfax County Public Schools, Division of Curriculum Services, 1976. Original activity by Ann Dorr.

TITLE: Rock Collecting Laboratory

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and Konrad Crist
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Chesterfield, Virginia 23832

PURPOSE: To provide "real world" experience for students in collecting and identifying different kinds of rocks, to observe their distribution, and to investigate their mineral content.

MATERIALS:
1. Nearby source of rocks such as parking lot or gravel area
2. Microscopes - preferably stereo with incident light source
3. Several identified representative specimens likely to be encountered (teacher should have some background in mineral identification)

PRE-LAB PREPARATION: This is a simple activity that can be done in the school yard or parking lot. The teacher must investigate and determine a study area suitable for the exercise. Students need to be prepared to work quickly. Such subjects as minerals and their identification must have been covered. Sedimentary, igneous and metamorphic rocks should also be covered beforehand. Emphasis should be placed on mapping and its importance when communicating a "rock find" to others. The teacher should take care to place the bounds on the study area. Caution students not to spend too much time drawing. Be sure to include the North arrow. This activity takes from 50-75 minutes.

PROCEDURE: The strategy is to collect rocks in the real world and identify them and their mineral content. Complete or answer the following as a result of your search.

1. Observe the entire search area. Make a sketch of this area on your own paper. Remember to include a North arrow.
2. Look at the way the rocks are spaced in the search area. What has caused them to occur in this way?
3. Mark with an "X" or shade the areas or places that are best for you to conduct your search.
4. Are there any major differences between the rocks in one part of your search area and another? It so, what might be the reason for this?

Collect three different-looking rocks. Try to name your specimens when you return to the classroom. Compare these to identified specimens in class. List the names of your rocks on your paper.

5. In the classroom look through the microscope and try to identify the minerals in your specimens.
6. What kinds of rock compose the study area?

CONCLUSION: As a result of the rock search the student should have been exposed to looking critically at a rock and identifying it and perhaps identifying the constituent minerals.

TITLE: Recycling Waste Paper

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Orange, Virginia 22960

PURPOSE: To make students aware of some of the conservation problems concerning our forests and to introduce them to a process of paper making using recycled materials.

MATERIALS:
1. fine screen
2. Kleenex
3. bowl
4. flat dish
5. food coloring
6. round jar or rolling pin
7. white blotting paper
8. starch
9. egg beater
10. newspaper

PRE-LAB PREPARATION: Background Information - Each day the forest has some influence on the way we live. Even in a treeless city, trees are important. Each family dwelling unit, whether an apartment or house, contains an average of about 13,000 board feet of timber in some form. Almost 32% of the wood cut each year goes into homes and furniture.

However, each year, the number of housing units built falls short of the minimum needs projected by Congress. There is a direct relationship between the housing shortage and the timber harvest. Materials suggested as substitutes for wood have proved costly; their manufacture has created environmental problems, and the resources they are derived from are not renewable.

Unfortunately, these are not the only demands on timber. Communication and education depend heavily on the timber harvest for paper and paper products. In this instance, however, man can do many things to conserve our woodlands. Recycling may provide part of the answer to this problem. This activity requires one 55 minute class period to complete.

PROCEDURE: Tear the tissue into very small bits and put them into a bowl. Add two cups of hot water and beat the mixture. Add two teaspoons of liquid starch and put in a few drops of food coloring (for colored paper). Pour the mixture into a flat dish and slide the screen under the mixture. Now lift the screen out carefully, hold it level and allow it to drain for a few minutes. Place it, pulpside up, on a blotter on a newspaper. Place another blotter over the pulp, and a newspaper over that. Roll a jar or rolling pin over it to squeeze out the water. Take off the newspaper, turn the blotter "sandwich" over. Lift the bottom blotter and screen very carefully-- this is your paper. Place a dry blotter on it. Replace wet newspaper with dry and press it with something flat for a few hours until it dries.

CONCLUSION: Discuss the importance of the implications of this activity on the conservation of the national forests. What new material is required for this recycling? What kinds of restrictions do properties of recycled paper place on its use?

TITLE: Mineral Resources-- Putting Things in Perspective

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INTRODUCTION: Minerals are the inanimate substances of which the earth is composed and on which all life depends. Mineral resources are the non-renewable concentrations of one or more elements in the earth's crust which can be extracted economically and with technologies available either at present or in the future. The concentrations have formed by infinitely slow geologic processes over tens of thousands to tens of millions of years. As far as our civilization is concerned, the resources are not renewable; once used they are gone, except for what man himself recycles. No combination of favorable economic conditions and advanced technology can supply resources that are not geologically available-- that nature has not concentrated.

Minerals are essential for food, for fuel, for homes, for clothing, for transportation, for communication-- for all of the functions performed by individuals and societies. Consumption is much greater in industrialized societies with high standards of living than in nonindustrialized societies.

During the last thirty years, the United States has consumed more minerals and more mineral fuels than all the people of the world used previously. (14) In the United States and other countries which have been industrialized for the last hundred years or so, high grade, easily accessible reserves of many essential mineral commodities have been largely exhausted. For other minerals, no more reserves exist. The industrialized countries rely more and more on imports. Iron and steel serve as an example of our reliance on minerals.

Steel, an alloy of iron with about 1.5% carbon (the exact amount is varied depending on the desired use), is the basic material of industrial society. Without large quantities of iron and steel products, the developed nations could not maintain their high standards of living.

> "At the present time, a country's heavy industry is the index of its material standard of living-- and iron and steel are synonymous with heavy industry. The ambition of many a newly emerging nation is to develop its own iron and steel industries. Steel has become the symbol of modern civilization and the representation of power in international affairs." (2)

PURPOSE: This exercise is intended to help students think of earth composition and mineral resources in terms of human society. It is intended to help them discover some of the problems of modern society with regard to supplies of steel, and to stimulate search for reasons and for possible solutions. Similar studies can be designed for other mineral commodities.

MATERIALS:
1. Large wall map of the world with countries
2. Small individual outlines maps of the world also showing countries
3. Information tables -
   a. I Materials used in producing steel
   b. II Imports of essential elements for the U.S. Steel industry
   c. III Percent of elements in earth's crust
   d. IV Population
   e. V Production and demand for iron and steel
4. Forms for graphs for procedure # 5, 7, 8, and 12 and form for Table for procedure #11.
5. Folders - one for each student to hold all work related to exercise

PRE-LAB PREPARATION:
1. Read the accompanying background information and become familiar with the glossary of resource terms and the classification charts. The first chart is detailed, the other simplified.
2. Select the chart suitable for your class and copy it on an overhead transparency or on the blackboard for use in discussion. Each student either should be given or should copy the chart you decide to use.
3. Duplicate enough world maps (unless you buy outlines maps), information tables, and forms for graphs so that each student can have a copy of each. If funds for duplicating are limited, a single class set of the information sheets will suffice ; however, students tend to mark on sheets when they work with figures so individual sheets are preferable. These should be placed in their folders.
4. Have each student purchase a folder and prepare it with the title of the investigation on the cover. Tell them the folder is to contain all of the materials connected with the investigation and that they will be expected to make an appropriate cover design for the folder.
5. Encourage students to collect any news clippings they find which are related to mineral resources, especially iron and steel.
6. Introduce the following doubling exercise and have students complete it at home before the investigation is done in class.
   a) Have students draw lines on a paper to represent a month on a calendar.
   b) Ask them to write "1" in the space for the first day. That represents their first day's allowance which is to be doubled every day for the month. Have them complete the calendar by filling in the doubled amount for each day. Let them do the first week in class. (Answers are included on page G-7-5.) This will be used in talking about population and use of resources.

PROCEDURE:
1. Discuss mineral resources as the foundation for society. Discuss the role of steel as the basic material of industrial society. Define terms and use the chart to explain their significance. Emphasize that certain elements or combinations of elements, is the ultimate determinant of mineral potential. If the mineral is not geologically available, no amount of money or advanced technology will produce it.
2. Have the class compile a list of things used by modern society which require steel. Group items by category.
   a) major structures (building, bridges, etc.)
   b) transportation (cars, railroad tracks, etc.)
   c) energy (drilling rigs, pipelines, transmission towers, power plants, etc.)

d), e), f), etc. - other classifications students may wish to use. List should be compiled on blackboard and copied by each student for his folder.

3. Discuss Information Table I, Materials Used in Producing Steel, and Information Table II, Imports of Essential Elements for the U.S. Steel Industry.
4. Have students plot on their maps of the world the locations of the countries from which the minerals used in steel come. Use a symbol or color for each material. Are most of the mineral resources used by the steel industry found in industrialized countries?
5. Have students make a bar graph to show percentages of each mineral commodity imported in 1976 and projected importations for 2000. (Figure 1)
6. Discuss the economic, political, and social implications of U.S mineral imports both to the U.S. and to the exporting country. How could U.S. demand affect world price?
7. Using Information Table IV, Population Information, have students make a graph to show the growth in world population from the stone age to the present and projected to the year 2050. (Figure 2)
8. On another graph, have students plot population from 1900 to 2000 for selected countries (U.S., Japan, Brazil, India). Use medium figures for 1985 and 2000. Use different colors for the different countries. Make a key. (Figure 3)
9. Discuss these graphs and relate them to the doubling activity. What does the information on population have to do with iron and steel?
10. Discuss Information Table V, Production and Demand for Iron and Steel. If projections are correct, how long will it take production and demand for iron and steel to double from the 1975 figures? How does this compare with the time for population doubling? What does this indicate about per capita demand for iron and steel between now and the end of the century?
11. Have students complete the attached table. Completed table is included on page G-7-6. Give students form of table without figures.
12. Have students make a bar graph to show comparative population, iron in ore production, iron in ore demand, and raw steel production for each of the four countries as percents of the world totals. (Figure 4)
13. The U.S. per capita consumption of steel products (and thus of iron and raw steel) is actually considerably larger than that of Japan yet the figures obtained in #11 indicate that Japan is a larger per capita consumer. Ask students to try to explain this inflation of per capita consumption figures for Japan.
    (Answer: Japan is a major exporter of finished steel products so that the Japanese people are not the ultimate consumers of many of the steel products. The U.S. on the other hand imports more finished products than it exports. Brazil is a great exporter of iron ore, but most of the steel products that it produces are used within the country and, at the present time, their steel imports are limited to a few specialized items which they can not yet produce. Japan's iron ore demand and imports represent what her steel industry needs for both domestic consumption and for export.)
14. If effective fertility controls are instituted worldwide at once so that world population reaches only 5,192 million by the year 2000, how much iron ore would be required to provide each person in the world with the average 1975 per capita demand for the U.S. (Answer: 1869 million tons contained iron).
    How much greater is that than estimated demand in 2000 A.D. from Table V? How many times greater is that than the 1975 world demand?

CONCLUSION: Have students review all of the information on their Information Tables and graphs.

Considering the raw materials required to make steel (including energy and water), the distribution of these materials, their relative abundance in the earth's crust, present and projected production and consumption figures:

a) what economic, political, and social problems do you foresee by the end of the century?
b) what possible solutions can you suggest?
c) what challenges does the 21st century hold in terms of non-renewable resources?

Answers to Pre-lab 6-b

Day 1	.01
Day 2	.02
Day 3	.04
Day 4	.08
Day 5	.16
Day 6	.32
Day 7	.64
Day 8	1.28
Day 9	2.56
Day 10	5.12
Day 11	10.24
Day 12	20.48
Day 13	40.96
Day 14	81.92
Day 15	163.84
Day 16	327.68
Day 17	655.36
Day 18	1,310.72
Day 19	2,621.44
Day 20	5,242.88
Day 21	10,485.76
Day 22	20,971.52
Day 23	41,943.04
Day 24	83,886.08
Day 25	167,772.16
Day 26	335,544.32
Day 27	671,088.64
Day 28	1,342,177.28
Day 29	2,684,354.56
Day 30	5,368,709.12
Day 31	$10,737,418.24

Table for Procedure #11

	1975 population in millions	percent world population	1975 iron ore production million short tons contained Fe	percent world population	1975 iron in ore demand million short tons Fe content	percent world population	1975 per capita demand iron in ore short tons	1975 raw steel production million short tons	percent world population
World	3,967	100	578.4	100	578.4	100	.146 (290 lbs.)	712.6	100
U.S.	214	5.4	51.4	8.9	77.5	13.4	.36 (720 lbs.)	116.6	16.4
Japan	111	2.8	0.5	0.09	84	14.5	.76 (1520 lbs.)	112.8	15.8
Brazil	110	2.8	64.4	11.1	12.4	2.1	.11 (220 lbs.)	9.2	1.3
India	613	15.5	28.5	4.9	11.2	1.9	.02 (40 lbs.)	7.8	1.1

(Note to teachers: Student should fill in data from their information tables. It is more meaningful to them if they themselves calculate the percents, but this may not be possible for classes where students are weak in arithmetic. In this case they could perhaps calculate one or two of the percents and you can help with the rest - or each student could be assigned one or two percentage problems and you could check accuracy, having all students record the answers.)

Information Table I

MATERIALS USED IN PRODUCING STEEL

Other than iron ore and scrap

A. Materials used to produce 1 ton of steel (amounts vary depending on process used)
   water - 60 to 150 tons
   limestone - 1/3 ton (removes SiO_2 from ore and makes slag)
   fluorspar - 3 pounds (makes slag more fluid)
   manganese - 15 pounds (scavenger: removes sulfur, oxygen, phosphorus, and other impurities)
   coke - 600 pounds (removes oxygen, supplies heat, supplies carbon)
   energy - 1.132 to 1.471 tons coal equivalent or about 33 million Btu's (av. bituminous coal 23,750,000 Btu per short ton) (3)

B. Materials in basic steel, an alloy of iron with an average of about 1.5% carbon

element	major ores	
iron	magnetite Fe_3O_4 (72.4% Fe)	
	hematite Fe_2O_3 (70% Fe)	
	geothite Fe_2O_3-H_2O (60% Fe)	Commonly known as limonite
carbon	coke derived from coal	carbon gives steel greater strength and hardness than pure iron, makes it malleable and ductile

C. Some of principal alloying elements for special steels

element	major ores (16)	function in steel (6,2)
chromium	chromite	stainless steel, hardenability, high temperature strength
cobalt	by-product of many minerals	strong permanent magnets, high temperature hardness
aluminum	complex mixture of aluminous minerals called bauxite	deoxidation, grain-size control
manganese	pyrolusite psilomelane cryptomelane todorokite nsutite	resistance to shock and abrasion, deoxidation, sulfur control, hardenability, toughness, durability
molybdenum	molybdenite ferrimolybdite	strength at high temperatures, corrosion resistant
nickel	pentlandite garnierite	stainless steel, high temperature alloys, electric resistance alloys, low temperature toughness
niobium (columbium)	columbite	prevention of internal corrosion (canneries), stabilizer to prevent fatigue in such things as springs and bridges
tantalum	tantalite	high melting point, resistance to corrosion, toughness, durability
titanium	ilmenite rutile	acid resisting (hardward for salt water boats, etc.)
tungsten	scheelite wolframite	hard carbide and hardened tool steel (drilling bits), high temperature hardness
	by-product of other mining	

Information Table I (cont'd)

element	major ores	function in steel
vanadium	mostly by-product of other mining and oil refining	high tensile strength, tool steels, armorplate, cutlery, structural steels, grain size control
zirconium	zircon baddeleyite	similar to manganese use

Information Table II

IMPORTS OF ESSENTIAL ELEMENTS FOR THE U.S. STEEL INDUSTRY

A. Major foreign sources of essential mineral commodities (16)

Commodity	Source where mined
iron	Canada, Venezuela, Brazil, Peru, Chile, Sweden, Liberia, Australia
aluminum	Jamaica, Australia, Guyana, Surinam, Guinea
chromium	U.S.S.R., Rhodesia, South Africa, Philippines, Turkey
cobalt	Zaire, Zambia, Finland
manganese	Brazil, Gabon, Australia, Zaire, South Africa
nickel	Canada
niobium	Brazil, Canada
tantalum	Brazil, Canada
titanium-	
rutile	Australia, Sierra Leone (Sierra Leone mine closed 1971)
ilmenite	Canada, Australia
tungsten	Canada, Australia, Bolivia, Peru, Portugal, S. Korea
vanadium	South Africa, Chile, U.S.S.R.
zirconium	Australia

B. Percent imported of total U.S. demand

Commodity		Forecast(1)	
	1976(13)	1985	2000
aluminum	90	96	98
chromium	89	100	100
cobalt	98	100	100
iron ore	35	55	67
manganese	98	100	100
nickel	71	88	89
niobium	100	100	100
tantalum	94	100	100
titanium-			
rutile	93	U.S. Production Data Confidential	
ilmenite	37	U.S. Production Data Confidential	
tungsten	59	87	97
vanadium	31	32	68
zirconium	U.S. Production Data Confidential		

Note:[16] Molybdenum is the only metal commodity of which the U.S. is a net exporter. The U.S. could be self-sufficient in aluminum, iron, and tungsten if prices were high enough

Information Table III

PERCENT OF ELEMENTS IN EARTH'S CRUST (16)

iron	5	niobium	.002
aluminum	8.13	tantalum	.0002
chromium	.02	titanium	.63
cobalt	.002	tungsten	.005
manganese	.1	vanadium	.01 - .015
molybdenum	.0001	zirconium	.026
nickel	.02		

Information Table IV

POPULATION

A. World Population Growth, Stone Age to 1975 (p1,p3)

date	estimated population	doubling time	average annual growth rate % during period
Stone Age			
400,000 BC	1,000,000		
20,000 BC	2,200,000	about 400,000 yrs.	0.0002%
6,000 BC	5,000,000	about 14,000 yrs.	0.005%
1 AD	250,000,000		
1650 AD	500,000,000	1,650 yrs.	0.3%
1750 AD	700,000,000		
1850 AD	1,000,000,000	200 yrs.	0.5%
1900 AD	1,550,000,000		
1930 AD	2,000,000,000	80 yrs.	0.8%
1950 AD	2,500,000,000		
1975 AD	4,000,000,000	45 yrs.	1.8%

The rate of population growth is determined by the difference between birth and death rates. The average rate of growth for the world today is about 1.8% annually but rates vary widely from country to country. In 1975 growth rates varied from -0.4% for Portugal to 5.9% for Kuwait. The growth rate for North America was 0.8%, for Latin America 2.8%.

An annual growth rate of 1% means doubling within 70 years; 2% per year will double in 35 years; 3% per year will double in 23 years.(p2)

In 1976, worldwide, 228 babies were born per minute and 93 people died each minute. As a result, the net population increase was 135 per minute, about 194,000 per day, about 1,358,000 per week, about 70,616,000 per year (one third the present population of the United States).(p2)

B. Population of the World and of Selected Countries 1900-1975 and forecasts for 1985, 2000, and 2050 in millions

date	World	U.S.	Japan	Brazil	India
1900	1,650 (p4)	76 (p5)	44 (p10)	18 (p11)	284 (1901) (p9)
1920	1,810 (p1)	92	55	27	306 (1921)
1940	2,246	132	71	41	389 (1941)
1960	2,972	181 (inc. Alaska and Hawaii)	94 (p8)	70	428 (p8) loss of Burma & Pakistan
1970	3,652 (p4)	205	104	94	543
1975	3,967 (p3)	214 (p3)	111 (p3)	110 (p3)	613 (p3)
1985 high	4,956 (p4)	239 (p7)	123 (p8)	149 (p8)	795 (p8)
med.		233	122	145	783
low	4,796	229	121	141	757
2000 high	5,486	283	134	232	1,124
med.		260	133	213	1,059
low	5,192	246	131	191	969
2050 high	13,444				
med.					
low	8,136				

Information Table V

PRODUCTION AND DEMAND FOR IRON AND STEEL
1965, 1975, and estimated 1985 and 2000

A. Iron Ore Production in millions of short tons of contained iron (Fe present in ore)

	1965(5)	1975(20)	1985(5)	2000(5)
U.S.	56.1	51.4	81	100
Japan		.5		
Brazil		64.4		
India		28.5		
World	362.3	578.4	757	1,130

B. Iron in Ore Demand in millions of short tons
(Iron in ore supplies about 60-70% of the iron for steel; the remaining 30-40% comes from scrap)

	1965(5)	1975(20)	1985(5)	2000(5)	probable growth rate 1973-2000
U.S.	82.2	77.5	107	129	1.5%
Japan		84.0			
Brazil		12.4			
India		11.2			
World	362.3	578.4	757	1,130	2.8%

(U.S. demand for iron in ore was down from 92.5 in 1973 and 90.8 in 1974, reflecting depressed production by the U.S. steel industry. This is due both to general economic situation and to increased competition from foreign steel producers. This competition has meant smaller exports of U.S. steel and greater imports of foreign products.)

C. Raw or Crude Steel Production in millions of short tons(20)
(Raw or crude steel is produced from iron ore and scrap iron. About 30% of raw steel becomes scrap before reaching the finished product stage. 1.43 tons of raw steel yield about 1 ton of finished steel.) (6)

	1965	1975	1985	2000
U.S.	134.1	116.6	190	260
Japan		112.8		
Brazil		9.2		
India		7.8		
World	523.6	712.6	940	1,410

BACKGROUND INFORMATION: Basic operations essential to the final production of steel in finished form can be divided into the following categories:

I. Geological exploration and the determination of reserves and resources
II. Establishment of mine and concentrating plant
III. Transportation of usable ore
IV. Manufacture of pig iron
V. Manufacture of steel

I. From the first indication that geological conditions in an area may be favorable to the existence of ore deposits to the final determination of reserves may require as much as 20 years or more. Assessment of the geologic availability requires knowledge of geology, mineralogy, geochemistry, geophysics. Reserve estimates are essential to mining companies so they can determine whether or not mining operations are economically feasible. Costs of exploration are large and must be included in the final cost of the ore if found, or charged off as loss if recoverable reserves are not discovered.

II. Setting up a large iron mine is an expensive operation costing tens to hundreds of millions of dollars. This cannot be done unless the mining company has assurance that reserves are ample to cover costs and yield a reasonable profit. Development of the mine and construction of the plant may require 3 to 7 years. A long lead time during which large sums of money are tied up is required before the product can enter the market.

Some of the factors considered in determining whether or not mining is economically feasible are:

1. Percent of Fe in the ore - This varies from about 30% recoverable iron to about 70%. The lower the percent of iron in the ore, the more rock has to be moved in mining and the greater the cost of concentrating.
2. Impurities - iron ore which is used for various types of steel can have only very limited amounts of such impurities as silica, sulfur, phosphorus, arsenic, copper. Removal of excess impurities is another cost factor.
3. Physical characteristics - Costs of mining and processing vary enormously, depending largely on the physical characteristics of the ore extracted. Much low grade ore, such as the taconite mined in Minnesota, is so hard that diamond drills or oxygen-hydrogen jet piercers must be used to prepare for blasting, which in such rock is also very expensive. This type of ore must be crushed and ground to the consistency of face powder to extract the iron minerals, a very expensive process. The iron minerals must then be agglomerated by balling and heating to white heat before use in the blast furnace. Other, generally higher grade, ores can be extracted with a minimum of drilling and blasting. All fine ores must be agglomerated before use in the blast furnace. Some hard high grade ores (65% Fe plus) can be fed directly into the steel furnaces after suitable sizing.
4. Taxes - Different states and countries tax mining operations in different ways. In some cases, taxes on reserves discourage thorough exploration; unidentified reserves cannot be taxed.

5. Environmental costs - In 1976, open pit mines (strip mines) accounted for 95% of the total output of iron ore in the United States. Environmental concerns involve the effect of mining on the land, large amounts of waste rock, and pollution of waters. Public concerns over need for minerals and desire to preserve the environment often conflict.

III. Transportation from the mine to the steel mill is complex and costly, particularly when the sources of ore are in relatively inaccessible places such as the interior of Brazil or Australia. Often special railroads must be constructed. Today in some places pipelines are used to transport a slurry, but this requires large amounts of water. Barges and ships also are important carriers of iron ore.

IV. Pig iron is produced in blast furnaces, where ore, coke, limestone, and other materials in smaller volume are subjected to a blast of air often enriched by oxygen or combustible gas at high pressures and temperature. Coke is a source of energy and acts as a reductant, removing the oxygen from the iron ore. Products of the blast furnace are slag, molten iron, and low-grade gas used in the plant as fuel. The iron may be cast in pigs or fed in molten state into the convertors which change it to steel.

V. Steel is produced from pig iron or hot metal from the blast furnace and scrap by a number of different processes. The amount of scrap that can be used varies with the process. About 30% of the raw steel becomes scrap before reaching the finished product. This scrap, together with scrap from worn out machinery and consumer goods, supplies between 30 and 40% of the iron raw material used in steel. Raw steel is further processed to produce the goods required by society. Steel plants vary enormously in size and cost as much as hundreds of millions of dollars.

In all of the above activities, energy and steel are inseparably linked. It requires enormous amounts of energy to explore for, mine, and process iron ores and to produce steel. The lowest grade of iron bearing formation that can be exploited is largely determined by the availability and costs of energy. In the other direction, it is estimated that the production of energy will require almost one third of all the iron and steel produced between 1975 and 1990.[17] The energy required to produce one ton of steel was calculated in 1960 to be the equivalent of about 1,132 to 1,471 tons of coal,[18,19] or about 33 million Btu's. (av. bituminous coal = 23,750,000 Btu's per short ton)[3] Much more energy is required in the entire process from exploration to finished product.

It is fortunate, considering our dependence on iron, that it is one of the most abundant elements in the earth's crust. The alloying elements are much less abundant-- in fact some are very rare, and they have numerous other uses besides as alloys of iron.

The relatively unindustrialized countries contain the largest reserves and probable resources of many of the required mineral commodities and are therefore major exporters to the industrialized nations, making it possible for them to earn foreign exchange to purchase manufactured items they desire. There is widespread concern that disportionate consumption of minerals by developed countries to support their high standard of living may ultimately deprive developing countries of resources essential to their hoped for industrialization.

Statistics related to iron and steel production and consumption become very complicated because of import-export activities at various stages. For example:

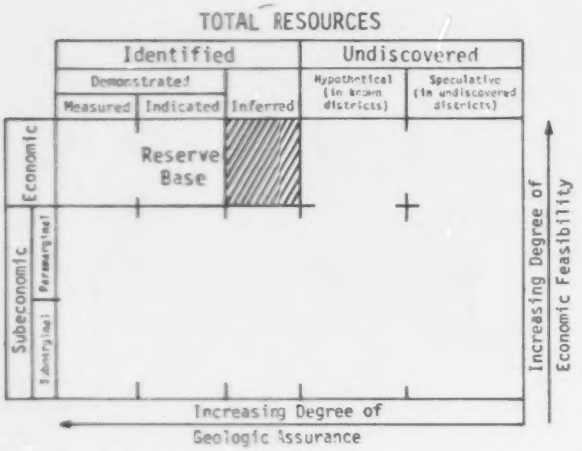
a) The U.S. mines less iron ore than it needs, it exports very little of the ore it mines, it imports a lot.

b) The U.S. produces from the iron ore (domestic and imported) much of the raw steel it uses to make finished products; however, it also exports a small amount and imports a larger amount of raw steel.

c) Most of the finished products of U.S. production are for domestic consumption, but, again, there are both imports and exports. In the past few years the U.S. industry has had reduced production due to foreign competition for both foreign and American markets. In 1975, U.S. imports of finished products were four times U.S. exports of finished products (12 million short tons imported vs. 3 million short tons exported). Statistics on finished products are extremely complex and it is almost impossible to come out with comparable figures on actual use by other countries, particularly for those in which finished products are significant in foreign trade. There are numerous reasons for higher costs of U.S. steel including higher labor costs, higher energy costs, use of low grade ores, obsolescent technology.

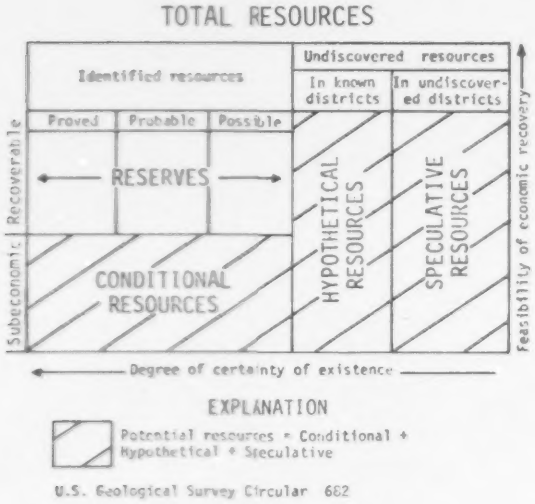
d) The U.S. is a net exporter of scrap.

CLASSIFICATION OF RESOURCES



SOURCE: BUREAU OF MINES

Classification of resources as published
In U.S. Geological Survey Bulletin 1450-A (18).



U.S. Geological Survey Circular 662

Resource- A concentration of naturally occurring solid, liquid, or gaseous materials in or on the Earth's crust in such form that economic extraction of a commodity is currently or potentially feasible.

Identified resources- Specific bodies of mineral-bearing material whose location, quality, and quantity are known from geologic evidence supported by engineering measurements with respect to the demonstrated category.

Undiscovered resources- Unspecified bodies of mineral-bearing material surmised to exist on the basis of broad geologic knowledge and theory.

Reserve- That portion of the identified resource from which a usable mineral and energy commodity can be economically and legally extracted at the time of determination. The term ore is used for reserves of some minerals.

The following definitions for measured, indicated, and inferred are applicable to both the Reserve and Identified-Subeconomic resource components.

Measured- Reserves or resources for which tonnage is computed from dimensions revealed in outcrops, trenches, workings, and drill holes and for which the grade is computed from the results of detailed sampling. The sites for inspection, sampling, and measurement are spaced so closely and the geologic character is so well defined that size, shape, and mineral content are well established. The computed tonnage and grade are judged to be accurate within limits which are stated, and no such limit is judged to be different from the computed tonnage or grade by more than 20 percent.

Indicated- Reserves or resources for which tonnage and grade are computed partly from specific measurements, samples, or production data and partly from projection for a reasonable distance on geologic evidence. The sites available for inspection, measurement, and sampling are too widely or otherwise inappropriately spaced to permit the mineral bodies to be outlined completely or the grade established throughout.

Inferred- Reserves or resources for which quantitative estimates are based largely on broad knowledge of the geologic character of the deposit and for which there are few, if any, samples or measurements. The estimates are based on an assumed continuity or repetition, of which there is geologic evidence; this evidence may include comparison with deposits of similar type. Bodies that are completely concealed may be included if there is specific geologic evidence of their presence. Estimates of inferred reserves or resources should include a statement of the specific limits within which the inferred material may lie.

Identified-Subeconomic- Resources that are not Reserves, but may become so as a result of changes in economic and legal conditions.

The terms proved, probable, and possible (used by industry for economic evaluations of ore in specific deposits or districts) commonly have been used loosely and interchangeably with the terms measured, indicated, or inferred (used by the Department of the Interior mainly for regional or national estimates). "Proved" and "measured" are essentially synonymous. "Probable" and "possible," however, are not synonymous with "indicated" and "inferred." "Probable" and "possible" describe estimates of partly sampled deposits--in some definitions, for example, "probable" is used to describe deposits sampled on two or three sides, and "possible" for deposits sampled only on one side; in the Bureau/Survey definitions, both would be described by the term "indicated."

Paramarginal- The portion of Subeconomic Resources that 1) borders on being economically producible or 2) is not commercially available solely because of legal or political circumstances.

Submarginal- The portion of Subeconomic Resources which would require a substantially higher price (more than 1.5 times the price at the time of determination) or a major cost-reducing advance in technology.

Hypothetical resources- Undiscovered resources that may reasonably be expected to exist in a known mining district under known geologic conditions. Exploration that confirms their existence and reveals quantity and quality will permit their reclassification as a Reserve or Identified-Subeconomic resource.

Speculative resources- Undiscovered resources that may occur either in known types of deposits in a favorable geologic setting where no discoveries have been made, or in as yet unknown types of deposits that remain to be recognized. Exploration that confirms their existence and reveals quantity and quality will permit their reclassification as Reserves or Identified-Subeconomic resources.

REFERENCES

MINERALS

1. Dorr, John Van N. II, Imports as Percentage of Total U.S. Demand for Selected Minerals-- Commodity Forecasts 1985 and 2000. Unpublished manuscript, U.S. Geological Survey.
2. Park, Charles F. Jr., Earthbound, Minerals, Energy, and Man's Future, Freeman, Cooper, and Company, San Francisco, California, 1975. (an excellent summary of earth materials as related to society)

UNITED STATES BUREAU OF MINES

3 Commodity Data Summaries, 1977

4-6 Chapter preprints from Mineral Facts and Problems, Bulletin 667, 1975

4. Introduction
5. Iron ore
6. Iron and Steel

7 Minerals in the U.S. Economy, Ten-year Supply-demand Profiles for Mineral and Fuel Commodities (1966-1975)

8-12 Minerals Yearbook, preprints

8. Iron Ore (1974)
9. Iron and Steel Scrap (1974)
10. Minerals in the World Economy (1974)
11. Statistical Summary (1974)
12. Iron and Steel (1975)

13. Status of the Mineral Industries, 1977

UNITED STATES GEOLOGICAL SURVEY

14 Circular #682 Summary of the United States Mineral Resources, 1973

15 Circular #698 Mineral Resources: Potentials and Problems 1974

16 Professional Paper #820 United States Mineral Resources, 1973 (The single most important publication on geology, origin, exploitation, uses, resources, problems of minerals)

17 Professional Paper #940 Mineral Resource Perspectives, 1975.

18 Professional Paper #1006-A, B Demand the Supply of Nonfuel Minerals and Materials for the United States Energy Industry 1975-90, A Preliminary Report 1976 (Detailed information on what and how much of different materials is required for use by the various energy industries)

19 United States Steel Company, The Making, Shaping, and Treating of Steel, p. 93, 1960.

20 Oral Communication, Charles Kimbell, Geographic Statistics Unit, Office of Technical Services, U.S. Bureau of Mines, November 23, 1977.

POPULATION

POPULATION REFERENCE BUREAU p. 1 - p. 3

p1 How Many People Have Ever Lived on Earth, Population Bulletin, February 1962

p2 Interchange, Population Education Newsletter, May 1976

p3 1975 World Population Data Sheet

p4 WORLD BANK, Population Planning, Sector Working Paper, March 1972.

p5 WORLDWATCH INSTITUTE, Twenty-two dimensions of the Population Problem Worldwatch Paper 5, March 1976. (Lester R. Brown, Patricia L. McGrath, Bruce Stokes)

p6 U.S. BUREAU of the CENSUS. Historical Statistics of the United States: Colonial Times to 1970, Part 1, 1975.

p7 U.S. BUREAU of the CENSUS. Current Population Reports, Population Estimates, and Projection. Projections of the Population of the U.S. 1970-2050, Series P-25-No. 704.

REFERENCES, POPULATION (cont'd)

p8 Population Division, Dept. of Economic and Social Affairs of the UN Secretariat, Selected World Demographic Indicators by Countries, 1950-2000 (ESA/P/WP.55) May 28, 1975.

p9 Chandrasekhar, S. India's Population, Fact and Policy. New York: John Day Co. for the Asia Press, 1946.

p10 Japanese Nat'l Commission for UNESCO, Manual of Demographic Statistics in Japan, March 1958.

p11 American Universities Field Staff. Fieldstaff Reports, "Population Review 1970: Brazil", East Coast South America Series, Vol. 14, No. 6.

p12. Huether, Carl A.,"Population: Facts & Materials for the Classroom," The Science Teacher, Vol. 41, No. 9, December 1974.

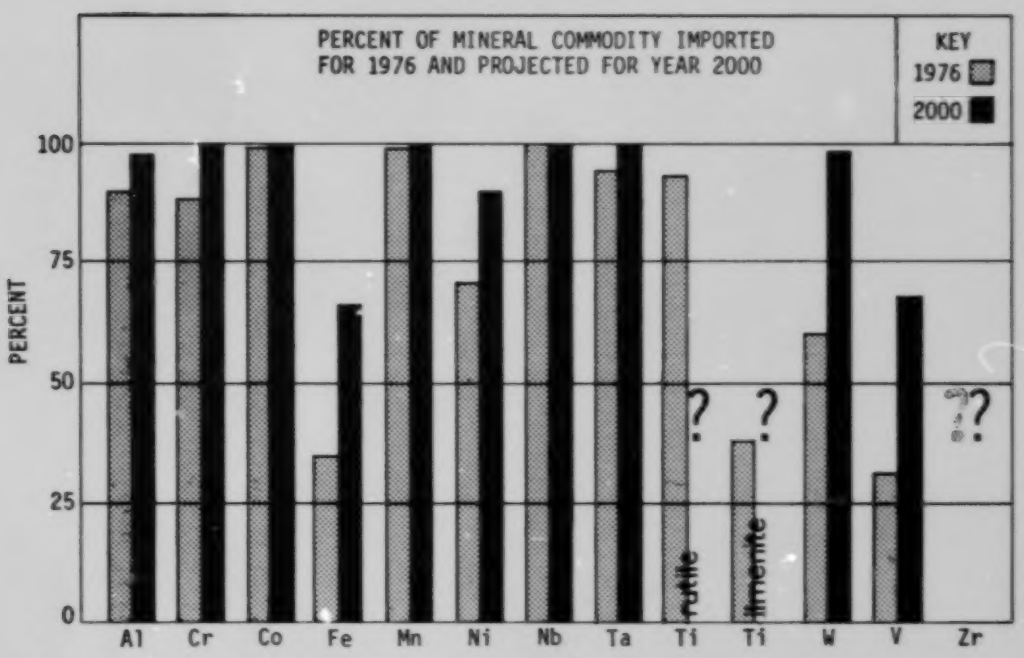


FIGURE 1

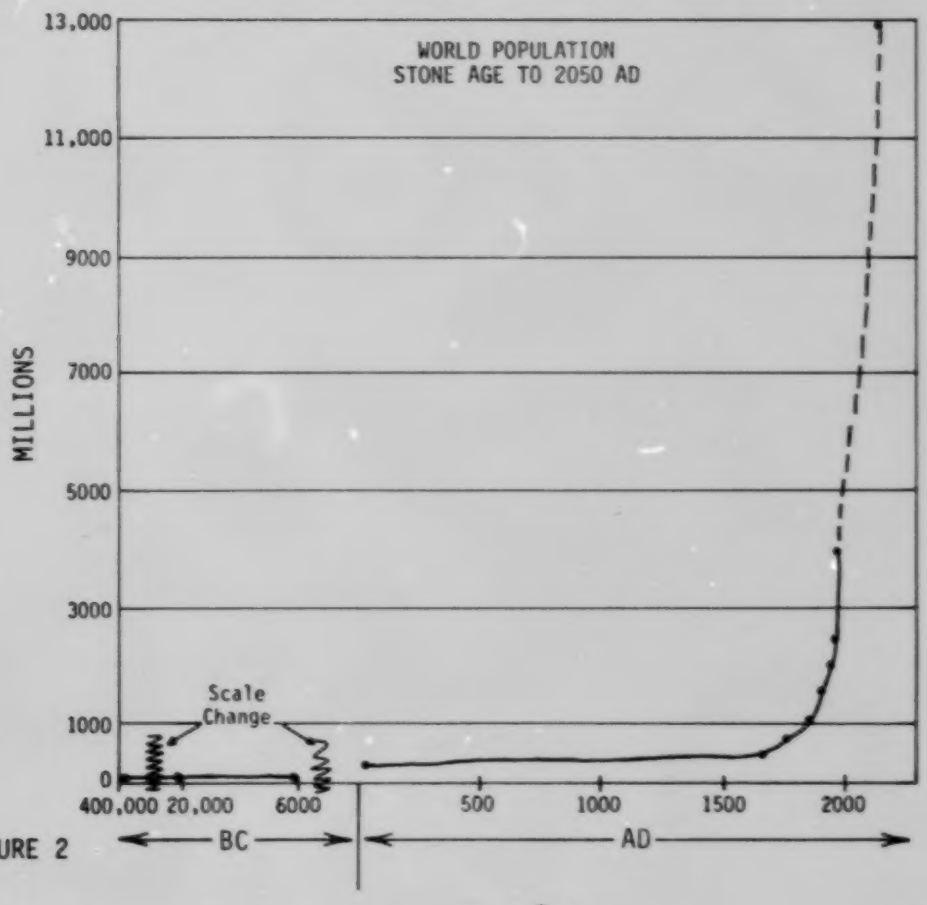


FIGURE 2

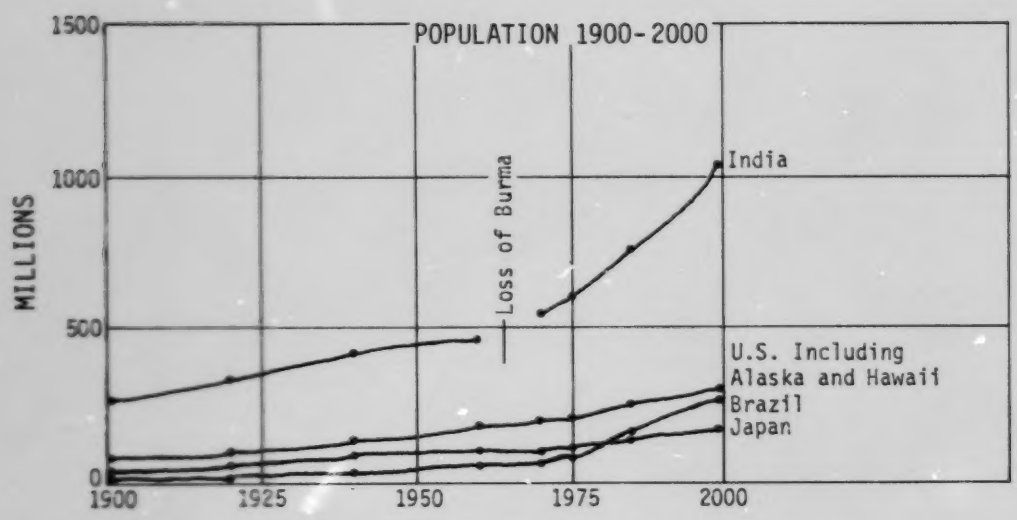


FIGURE 3

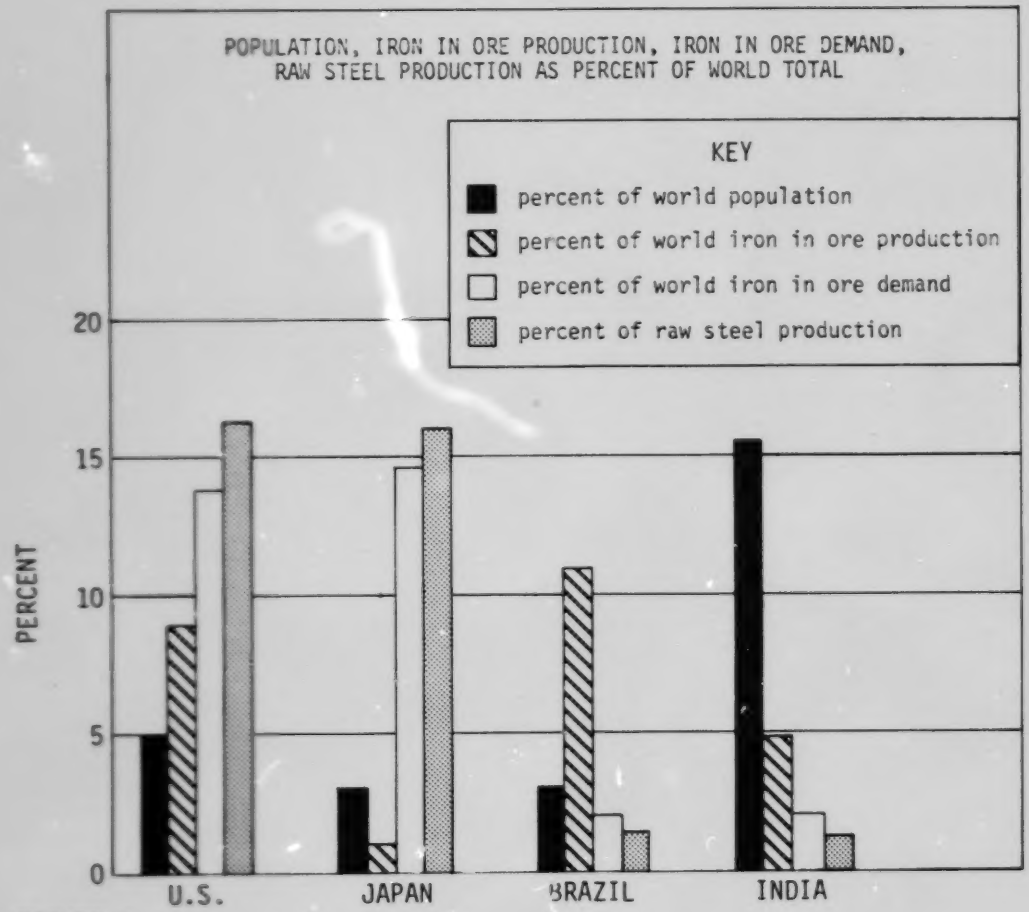


FIGURE 4

TITLE: It's Geologic - A Review Game

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PURPOSE: To provide a fun activity as well as a viable review of a subject area.

MATERIALS:

1. 30-60 questions per class period
2. supplementary slides or transparencies for questions (if needed)
3. timer or clock

PRE-LAB PREPARATION:

1. Students should be divided into four groups.
2. There should be three rounds of questions. The team that has accumulated the greatest number of points at the end of the game is declared the winner. The reward for the win depends on the preference of the individual teacher. Some teachers excuse the students on the winning team from taking the test and giving them an A for the test; other teachers have given the members of the winning team 20 points on the test.
3. Choose three student volunteers to: A. Keep score, B. Ask questions and C. watch the clock and indicate which team signals first. These students can receive the same reward as the winning team. The teacher is free to observe the class participation and to act as a judge.
4. Time for answering each question should be 30 seconds. When a team is recognized the answer is given by the team captain or a team member.
5. There can be many variations to this activity and the types of questions that can be used are varied. For example;
   - Completion,
   - Multiple Choice (one chance only),
   - True-False (one chance only),
   - Matching-must match all to get credit (use transparency),
   - Diagram-parts can be identified.
6. Have questions written on index cards along with the answers. If visuals are needed make a note on the card (e.g. Transparency #1, slide #2, etc.)

PROCEDURE:

1. Each round should last about 19 minutes.
2. Round one is a build up round. Each team is asked a question in turn. Students are given 30 seconds in which to answer. For each correct answer 5 points are awarded. If they answer incorrectly there is no penalty.
3. Round two is a toss up round. Any team captain or team member may answer. The first person who signals must answer. If correct, 10 points are added to the team's score; if incorrect, 5 points are taken away.
4. Round three is the bidding round. Each team in turn decides on the bid of 20 points, 15 points, or 10 points. Twenty points for three questions, 15 for 2 and 10 for 1. All questions must be answered correctly for credit. The team is penalized the number of points bid, if incorrect.
5. A fourth round is optional, a quick recall round played like the toss up round. This gives a review of difficult areas.

TITLE: The Geologic Puzzle

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INTRODUCTION: This is a model which has been classroom tested. The variations of it are practically unlimited. This activity should be used, as it is described, after students have studied the principles listed below. However, it could be modified to be used as an introduction to these principles.

Sequence of activities;

Pre-lab - 30 minutes

Explain the model, discuss the horizontal and vertical scale, and have a brief discussion of how geologists might begin an investigation of a part of the earth's crust.

Laboratory Investigation - Five, 55 minute periods

Students collect data, make maps and models, and write reports.

Post-lab Discussion - 55 minutes

After an evaluation of the results, direct a discussion of the methods used, and the interpretation of earth history developed by the students.

PURPOSE: This investigation enables students to interpret a part of the earth which has been reconstructed in the classroom. Students can apply many of the principles used in field geology including measurements, map construction (topographic and geologic), construction of geologic profiles, identification and correlation of rock layers, identification and correlation of fossils, and interpretation of earth history.

PRE-LAB PREPARATION: The equipment used is that found in the ESCP materials and listed in equipment catalogues. The entire activity will take approximately six, 55 minute class periods.

Rock samples:
- sandstone
- shale
- quartzite
- gneiss
- granite
- basalt
- gabbro
- red sandstone

Plastic Fossils:
- Mucrospirifer
- Spirifer
- Meekoceres

Hardware:

16 ring stands
18 plastic columns with caps
16 meter sticks
16 burette clamps
Student Instruction Sheet for basic fossil kit(included)
clay
beakers
masking tape

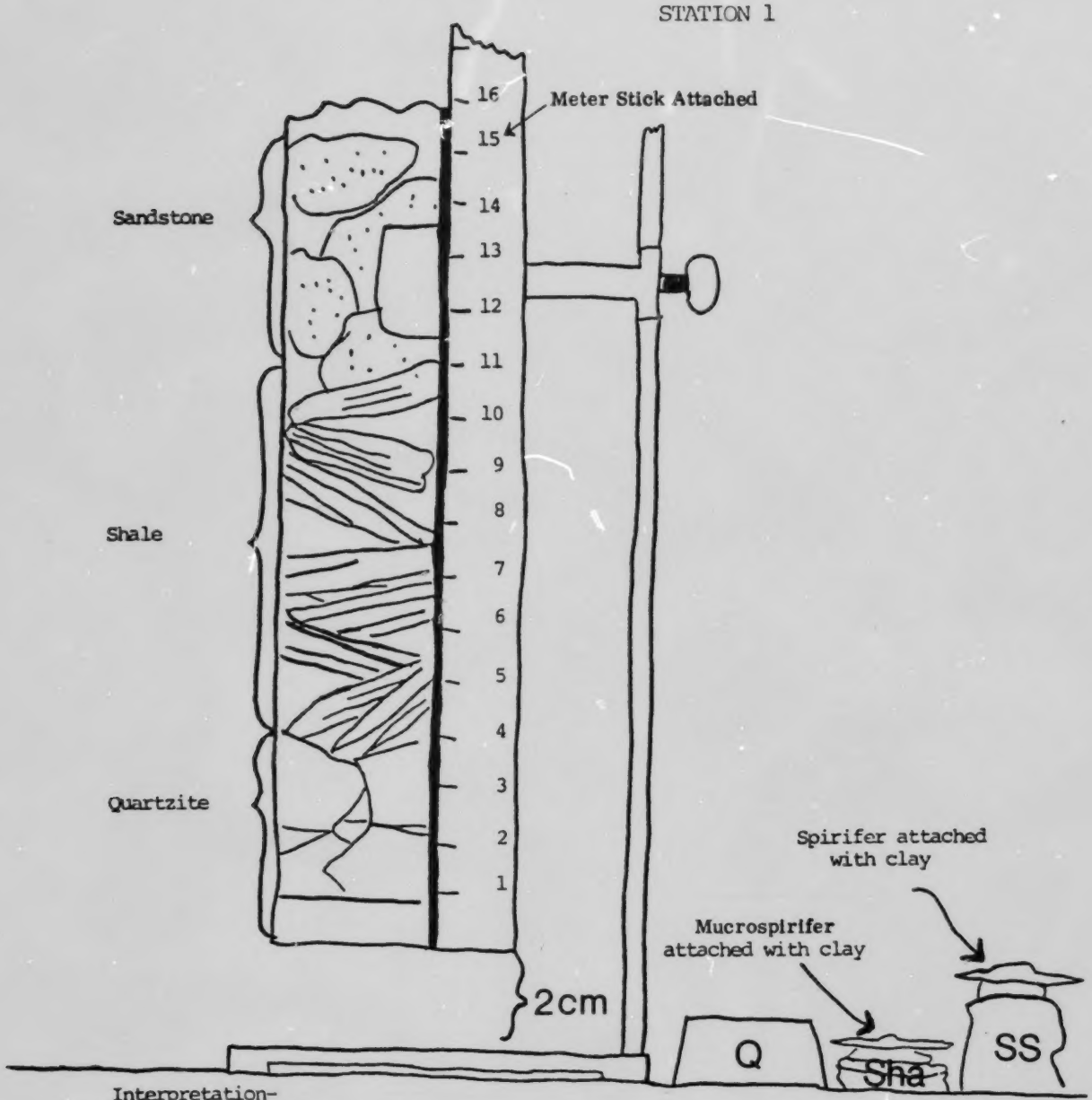
ADVANCE PREPARATION: The columns of rocks with samples and fossils must be set up well in advance. This will take several hours the first time. Tables must be arranged and the model set up in a room and preferably left in place for the five days of observation. Positions of stations could be marked and the materials removed and returned if the room is used by other students or classes. Station position maps and general instructions must be duplicated.

PITFALLS AND CAUTIONS:

1. Do not tell the students too much. Respond to students questions with leading questions. Encourage original interpretations and accept alternate interpretations.
2. Caution students not to move the columns.
3. Work through the procedure with the students as a member of the "research team."

SETTING UP THE MODEL: A detailed sketch of station #1 is shown on the following page followed by a chart showing what is in each column for each station. Outside of the column at each station is a sample of each rock which is found in the column and fossils which are found in the sedimentary layers are attached to the outside samples with clay. Each column should follow the same general procedure using the chart as a guide.

STATION 1



Interpretation-
Elevation 170 meters

	Fossils	Age
Sandstone 40 meters	Spirifer	Mississippian
Shale 70 meters	Mucrospirifer	Devonian
Bottom Quartzite 40 meters		

STATION NUMBER		1	2	3	4	5a	5b	6	7	8	9
Elevation to top of top-layer above ring stand		17	30	68	42	36	6	29	18	33	37
All Measurements are in Centimeters Key Spirifer (Sp) Mucrospirifer (MSp) Meekoceras (M)	Thickness of Layers 4					B 7	B 7	B 6			
	Thickness of Layers 3	SS 4 (Sp)	Q 3		Q 6	SS 5 (Sp)	RSS 6 (M)	RSS 6 (M)	SS 5 (Sp)		Q 7
	Thickness of Layers 2	Sh 7 (MSp)	Gn 5		Gn 5	Sh 6 (MSp)	SS 5 (Sp)	SS 6 (Sp)	Sh 6 (MSp)	Gn 6	Gn 3
	Bottom Layer	Q 4	G 5	G 11	G 3	Q 6	Sh 6 (MSp)	Sh 5 (MSp)	Q 7	G 7	G 4

Station Number		10	11a	11b	12	13	14	15	16		
Elevation to top of top-most layer above ring stand		36	28	28	26	29	58	59	41		
Key Sandstone SS Red Sandstone RSS Granite G Gneiss Gn Quartzite Q Bassalt B Gabbro Gab. Shale Sh	Thickness of Layers 5				SS 4						
	Thickness of Layers 4				Sh 6 (MSp)	Sh 5 (MSp)					
	Thickness of Layers 3	SS 5	SS 5	RSS 3	Q 6	Q 5					
	Thickness of Layers 2	Sh 5 (MSp)	Sh 6 (MSp)	SS 4 (Sp)	Gn 4	Gn 5			B 8		
	Bottom Layer	Q 6	Q 5	Sh 6 (MSp)	G 6	G 7	G 5	G 5	Gab. 15		

G-9-4

INSTRUCTIONS TO THE STUDENTS AND TEACHERS:

To the students--

Consider yourself a geologist who is asked to investigate a section of the earth which has never been investigated before. For budget and other reasons, the number of stations which you can study will be limited to those sixteen places shown on the map.*

At each station the column of rocks represents the kinds of rocks and the thicknesses of rocks found at that location. Beside the column is a sample of each rock found in the column for you to observe.

A. Sea level (0 meters elevation) is the top of the ring stand base.
B. Every 1 cm measured upward from the base represents 10 meters. (The top layer of rock at Station 1 is 4 cm thick. This layer would then be 40 meters thick.)
C. The top of the uppermost layer of rock is the elevation above sea level at that station. (At Station 1, the top of the uppermost layer is 17 cm above the ring stand base, therefore, the elevation at Station 1 is 170 meters above sea level.)
D. Fossils are attached to the rocks in which they were found.

To the teacher--

*At this time give out the map and help orient the students as to where the stations are in the room. Discuss the scale of the map.

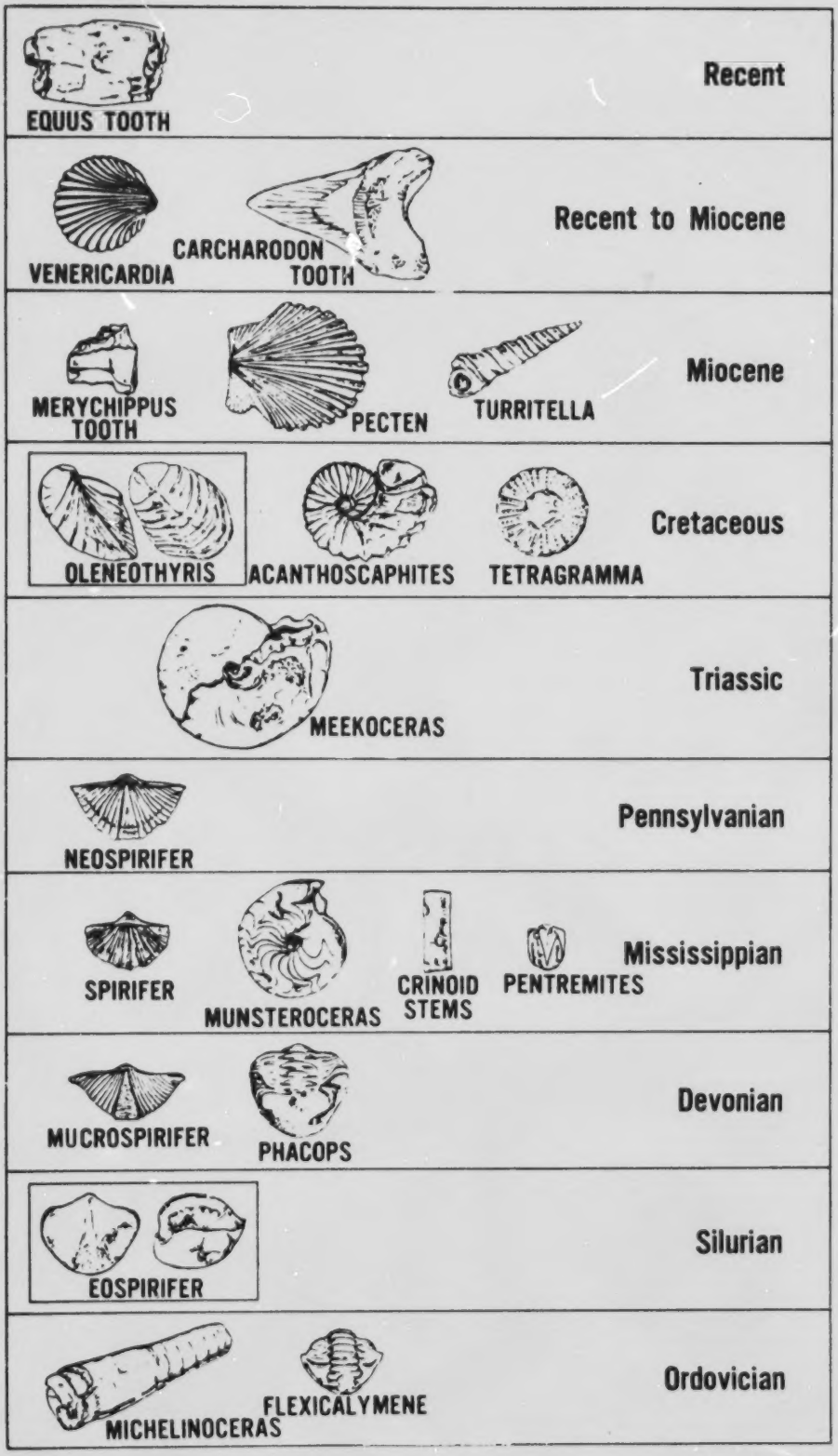
Discuss the above description of the model to make sure that students understand the model.

Ask students how a geologist would begin. What should be done first? Try to direct the discussion to include:

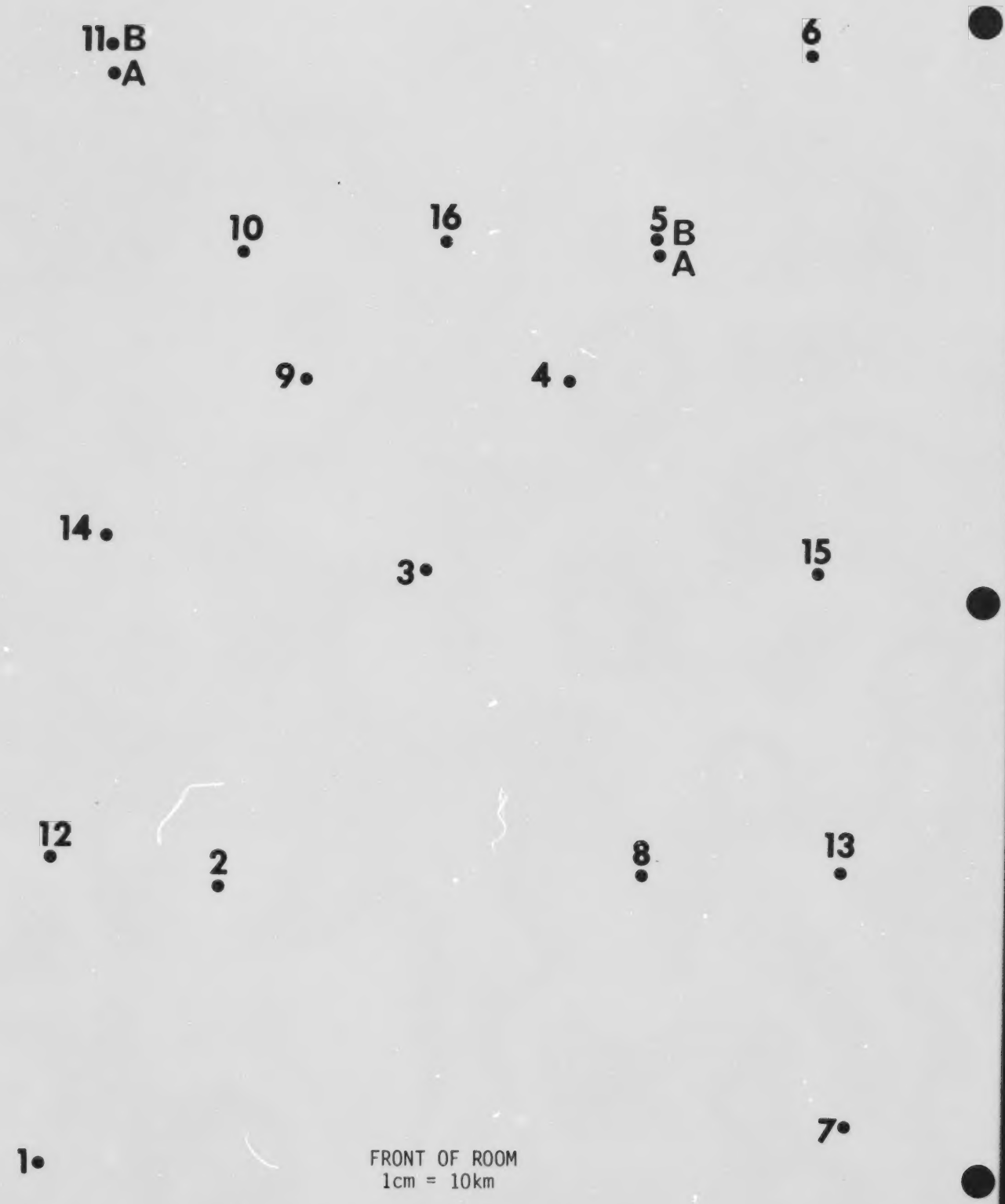
A. What does the area look like (topography)?
B. What are the rocks like (geologic maps and profiles or models)?
C. What has been the history of the area which has led to its present topography and geology? What history is recorded in the rocks?

The specific objectives are for each student to describe each of the above at the end of one week of investigations.

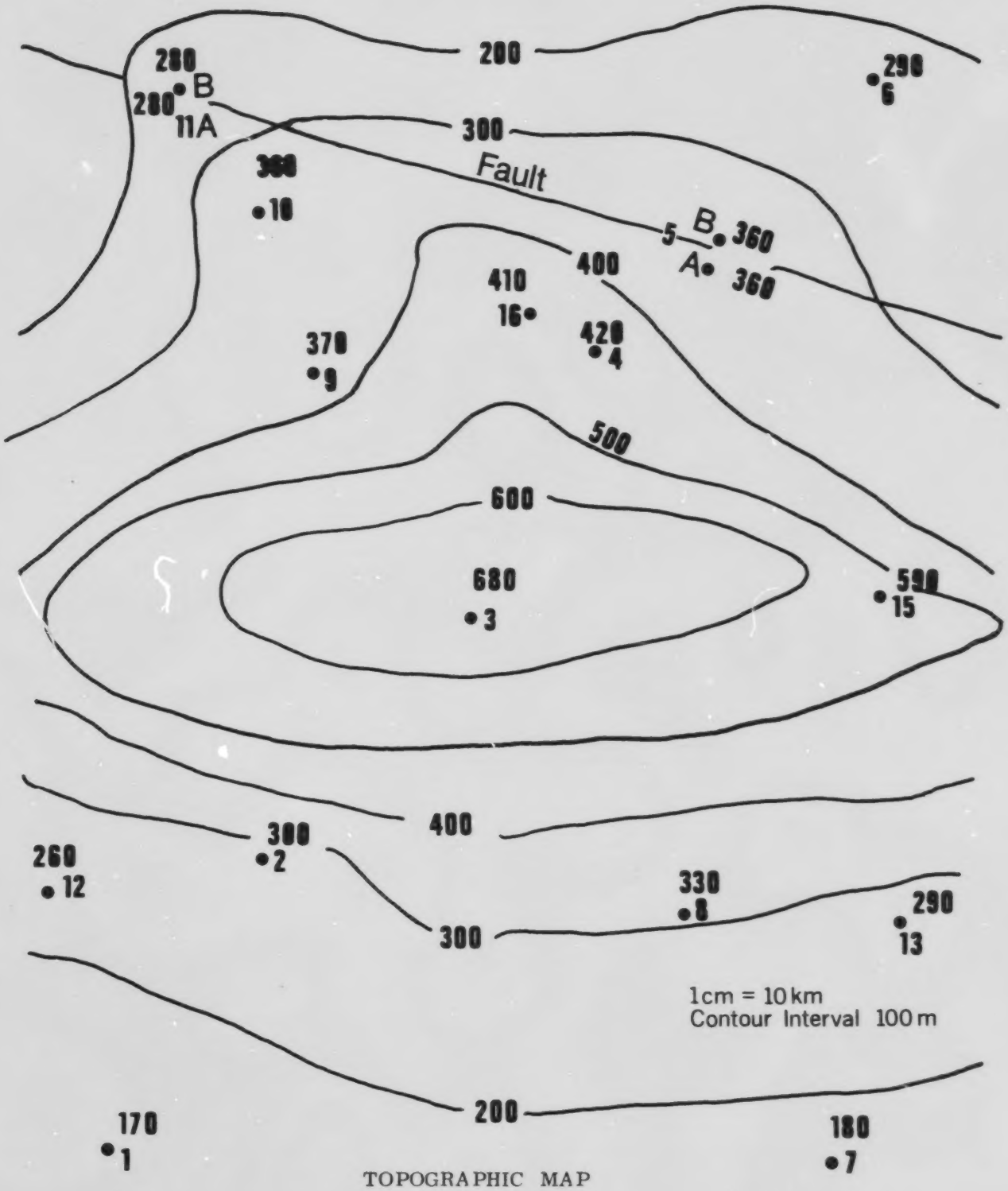
RESULTS: Students will begin to ask questions and should be allowed to probe for the remainder of the first period. Ask them to come in tomorrow with a plan of attack. If the students are near completion of the ESCP course, they will have drawn isolines, contour lines, etc., since early in the year and with some suggestions may be able to draw a topographic map of the area. Students might have drawn geologic profiles in the "James Hall field trip," "Michigan Basin," and "Ice Age Puzzle." They might have had considerable practice in interpreting the record in the rocks. This activity is a chance for better understanding much of the year's work.



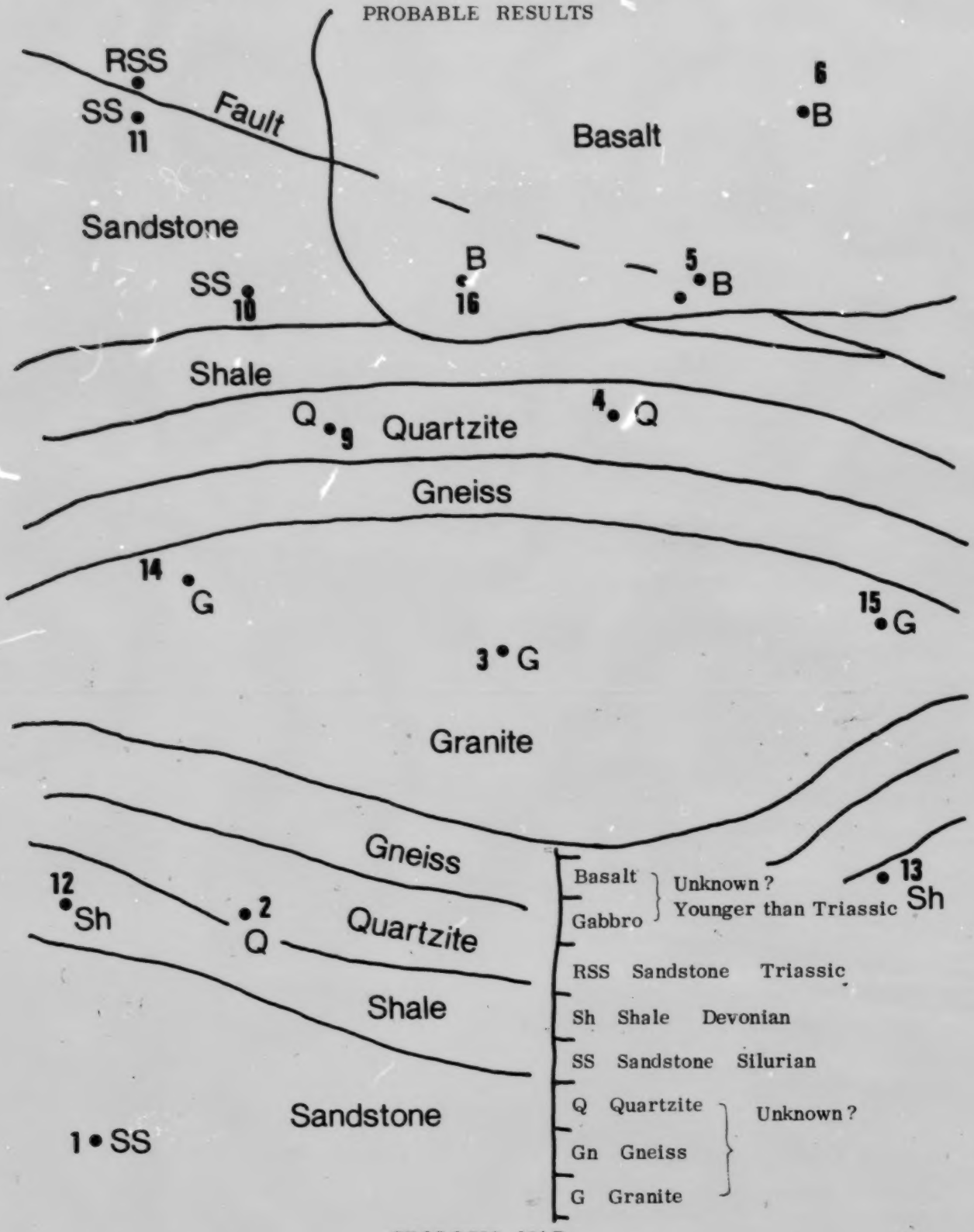
This chart adapted from Investigating The Earth Teachers Guide Part I (1967) page 409.



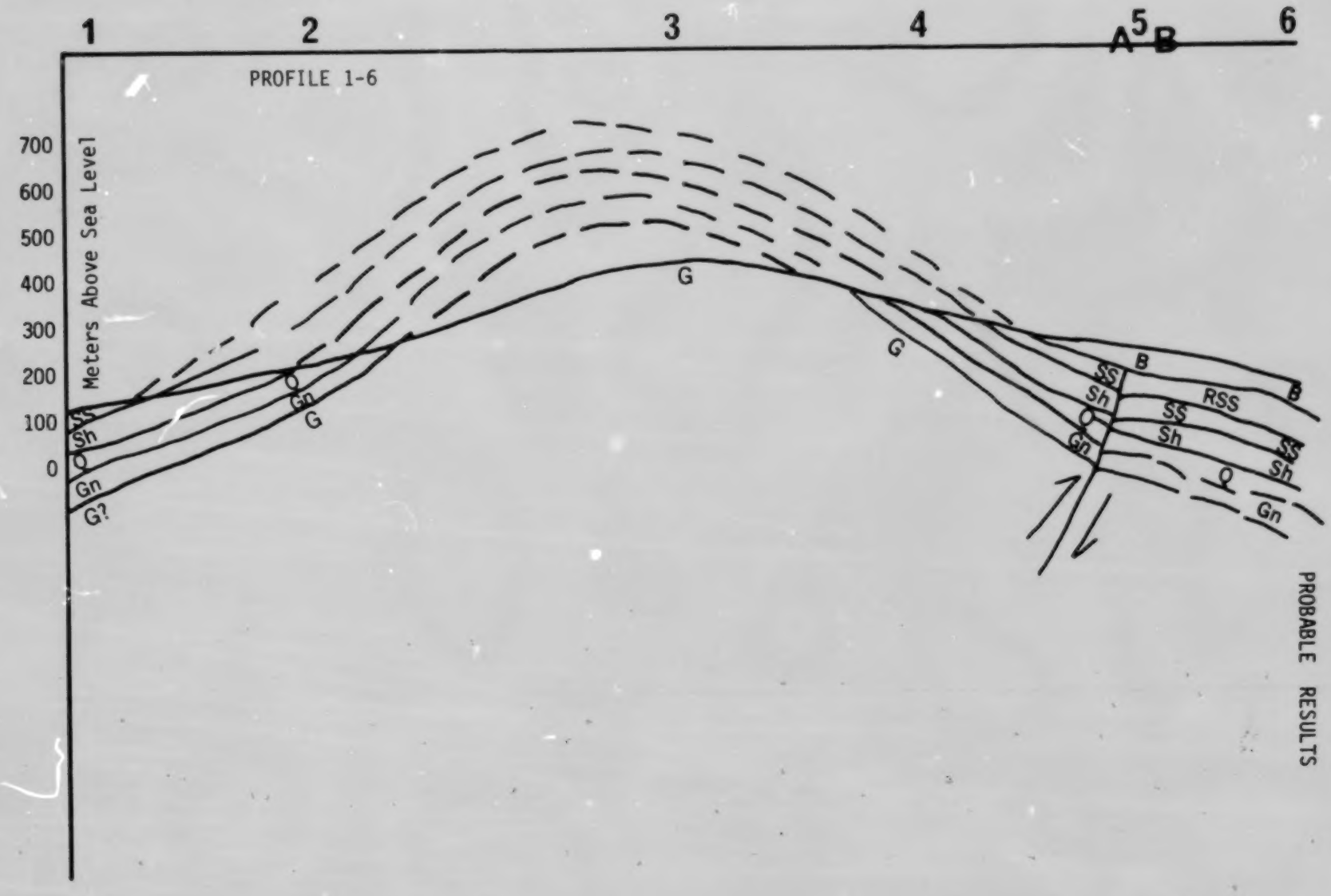
FRONT OF ROOM
1cm = 10km



TOPOGRAPHIC MAP



GEOLOGIC MAP


1
2
3
4
5
A
B
6
PROFILE 1-6
Meters Above Sea Level
700
600
500
400
300
200
100
0
SS
Sh
Q
Gn
G?
G
B
RSS
G-9-10
PROBABLE RESULTS

Possible Student Interpretation of Data.

Arranged from most recent event to oldest event.

7. Erosion of the present land surface.

6. Volcanism occured at station 16 to produce gabbro and a basaltic lava flow which covered the northeast area, during or after the Triassic.

5. Probable submergence during the Triassic and accumulation of sediments which formed red sandstone north of the fault.

4. Uplift of area. Faulting from stations 5 through 11, followed by a period of erosion.

3. Contact metamorphism to form gneiss and quartzite.

2. Intrusion of granite or formation of granite from extreme metamorphism.

1. Deposition of sediments probably in a geosyncline beginning before the Silurian and continuing through the Devonian.

METEOROLOGY

TITLE: What's in the Air?

H. B. Lantz
and Janice O. Wax
Orange County Schools
Orange, Virginia 22960

PURPOSE: To determine some of the different types and amounts of material that can be found in a sample of air.

MATERIALS:

1. piece of waxed paper (6 cm square)
2. pencil
3. ruler
4. piece of cardboard (7 cm square)
5. Vaseline
6. thumbtacks
7. hand lens or microscope

PRE-LAB PREPARATION: The teacher should instruct students to use a pencil with a dulled tip. Otherwise, a too sharp pencil can rip the waxed paper. The students should also be reminded to place their cardboard and paper in a secure place in their backyards, and in a place where air moves freely. It should also be noted that Vaseline is extremely greasy, and students will need to wash their hands. Since soap doesn't remove Vaseline well, the teacher should invest in a small box of dishwashing detergent. A small amount used along with soap will generally remove the Vaseline quite easily.

PROCEDURE: Obtain a piece of waxed paper 6 cm square. The student may wish to make the paper slightly larger so that a small boarder will extend around the edges. This small border can be useful when tacking the paper to the cardboard. Use a pencil and ruler to mark the waxed paper so that it is divided into cm squares. When the grid is completed, the student should have 6 squares across, and 6 squares down. Attach the waxed paper to the piece of cardboard with thumbtacks. Coat the paper evenly with a thin layer of Vaseline.

Select an open place near your home where the paper can remain undisturbed for a week or longer. At the end of this time, examine the paper with a hand lens or microscope for materials which stick to Vaseline. The teacher may wish to make acetate copies of the different student grids for use on an overhead projector.

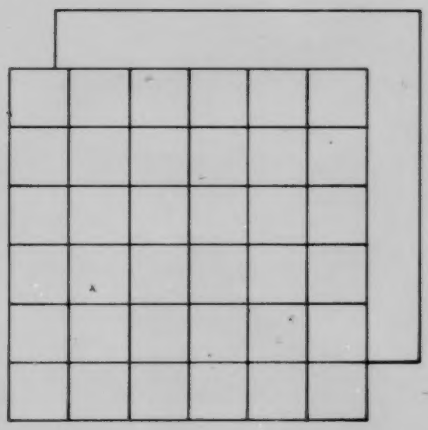


Figure I, Waxed Paper Design

STUDENT QUESTIONS:

1. Why is Vaseline used to coat the waxed paper?
2. Why does the board and paper have to remain in an undisturbed place, where air is free to flow?
3. Using a hand lens or microscope describe the general types of materials found on the waxed paper.
4. Choose one of the squares and count the number of different types of materials that can be found on it.
5. Select four squares and compare the types of materials found in the first square to the types of materials found in the other three squares.
6. Organize this information into a graph. A bar graph would probably be the easiest method to represent the data.
7. During which time of the day would you expect the most solid particles to become stuck to the waxed paper? Why would you expect this to be true?
8. Which member of the class found the most materials stuck to his waxed paper? Is there anything about the location of this particular person's home that would suggest why this would be true?
9. If this activity were done one year from today, would you still expect there to be the same amount of material on the waxed paper? Explain your answer.

CONCLUSION: The students can be expected to find a variety of dust particles, pollen grains, dirt, small insects and other materials on their Vaseline sheets. Differences in the materials found might reflect closeness to highways, smokestacks, incineraters, or heavily traveled areas. The types of materials found might also reflect the season of the year, this the teacher might wish to discuss with the students.

EXTENSION: Another version of this experiment, based on this material, might be to have the students place their grids out in their backyards at different times of the day. This procedure might show the height of pollution periods during a particular 24-hour period. An additional activity would be to place clean grids in the same location before and after a rainstorm and do a particle comparison.

TITLE: Do Hurricanes* Happen Haphazardly?

Sharon Charles
and Richard Scheele
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Mechanicsville, Virginia 23111

PURPOSE: By using latitude and longitude, plot the paths of hurricanes in the Northern and Southern Hemisphere.

MATERIALS:

1. map of world (included)
2. pencil
3. hurricane path data (included)

PRE-LAB PREPARATION: Make copies of world maps for all students. Activity takes one 55 minute class period.

PROCEDURE:

1. The entire class should do the initial hurricane paths entitled West of Hawaii together. Then each student should continue plotting the remainder of the paths at his own rate.
2. Look at your data sheet. Find Roman Numberal I entitled, West of Hawaii. Notice there are 5 sets of numbers. The latitide is listed first and the longitude is listed next. Locate 5^{o} North latitude with your finger. With another finger, locate 155^{o} West longitude. Move your fingers until they meet. Place a pencil dot at this point. Repeat this procedure with the next four sets of numbers. Connect these dots with a line in the order you plotted them and place an arrow after the last dot.
3. Plot the next hurricane path entitled West Coast of U.S. Notice that when you finish this path you will have four dots since there are only four sets of numbers.
4. Continue to plot the other hurricane paths. Be neat and be careful that you are locating the correct latitude and longitude.
5. On your map and beginning with Roman Numeral I, give each hurricane a woman's name. Use a name which begins with an A, such an Andrea, and continue to name each other hurricane with a name that starts with a different letter.

CONCLUSION:

1. What is the latitude in the Northern Hemisphere at which hurricanes usually originate?
2. Now you are ready to answer the question to the title: Do Hurricanes Happen Haphazardly?

EXTENSIONS:

1. Why can hurricanes not cross the equator?
2. What is the possible source of the hurricane's energy?
3. What could be the reason that hurricanes do not occur in the South Atlantic?

*Also called typhoons, etc.

Paths of Twelve Hurricanes in the Northern Hemisphere

I. West of Hawaii	II. West Coast U.S.	III. Southeast U.S.
5N : 155W	15N : 100W	15N : 50W
10N : 165W	20N : 105W	15N : 60W
15N : 172W	25N : 110W	20N : 75W
30N : 180W	30N : 116W	25N : 90W
40N : 165W		33N : 99W

IV. Southeast U.S.	V. Southeast U.S.	VI. Southeast U.S.
14N : 77W	7N : 20W	10N : 60W
20N : 80W	7N : 30W	15N : 65W
30N : 85W	7N : 45W	25N : 70W
	15N : 60W	30N : 75W
	22N : 68W	35N : 70W
	30N : 60W	40N : 60W
	45N : 45W	

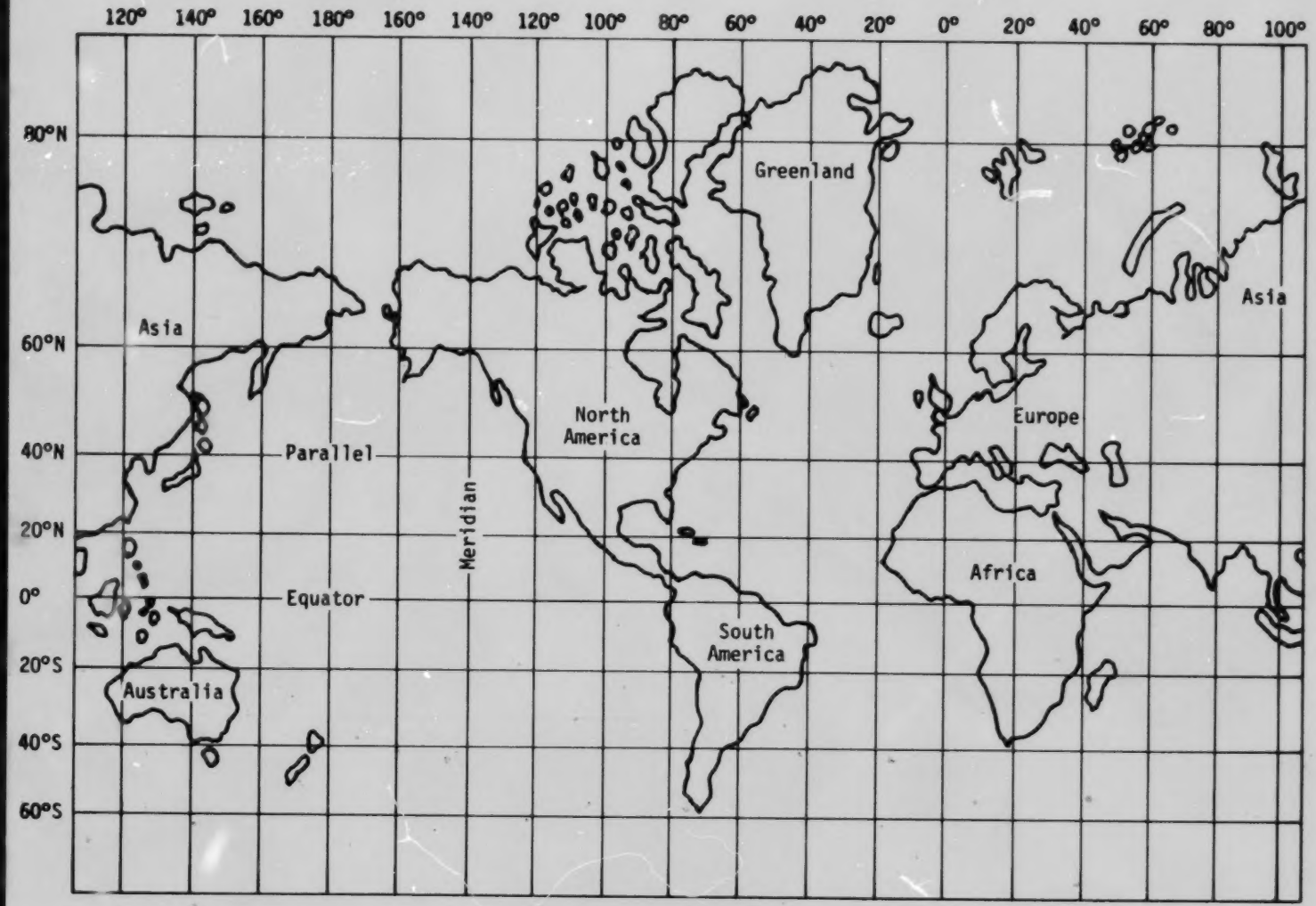
VII. East Pakistan	VIII. India	IX. East Vietnam
10N : 75E	10N : 95E	5N : 150E
15N : 70E	15N : 80E	15N : 135E
30N : 65E	20N : 75E	15N : 120E
		20N : 105E

X. Japan	XI. China Sea	XII. East Japan
5N : 150E	7N : 150E	7N : 150E
10N : 135E	15N : 135E	15N : 133E
15N : 130E	20N : 130E	20N : 135E
25N : 125E	25N : 125E	25N : 137E
30N : 128E	30N : 120E	30N : 140E
40N : 135E		40N : 150E

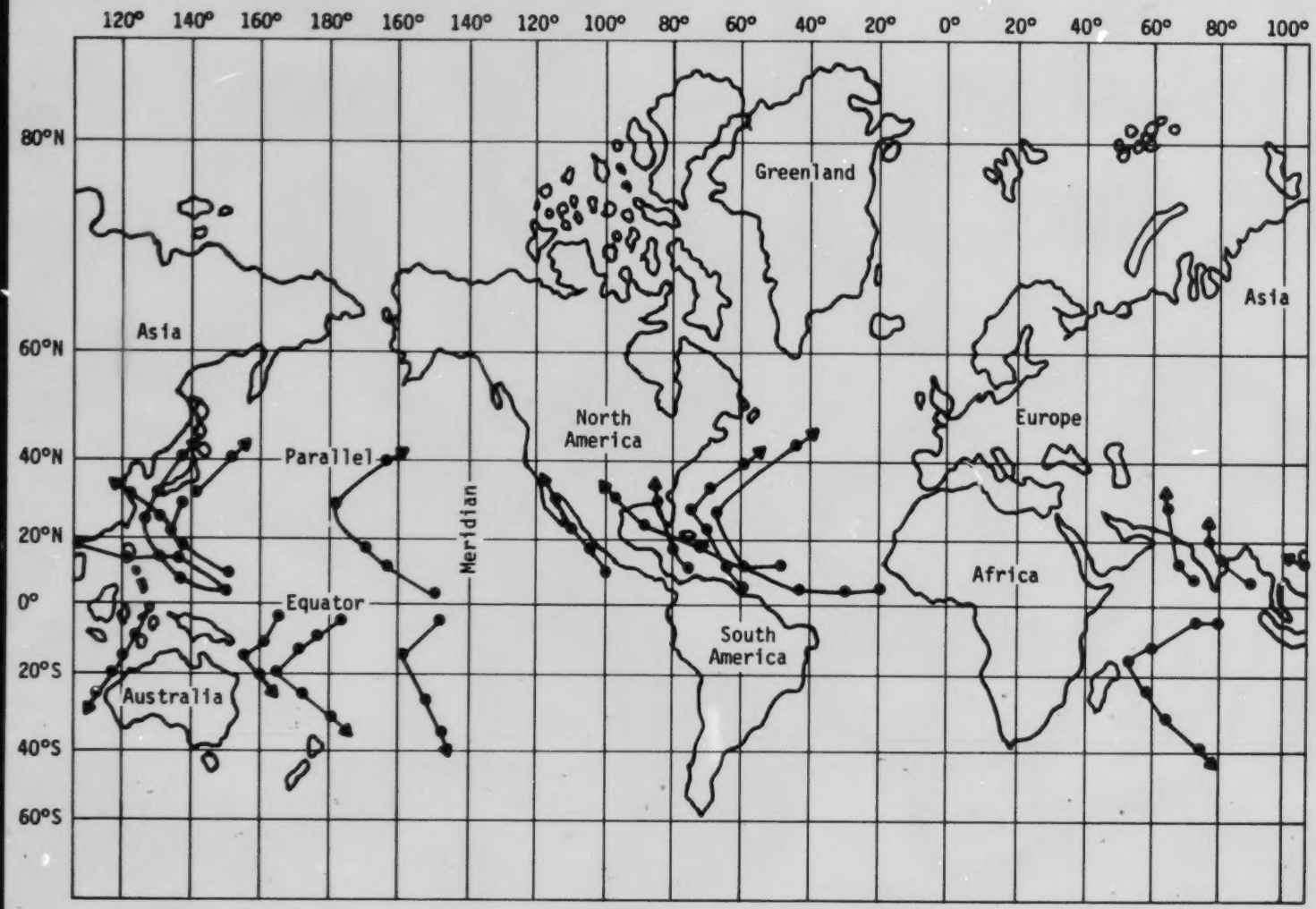
Paths of Five Hurricanes in the Southern Hemisphere

I. East Australia	II. East Australia	III. Western Australia
5S : 179W	5S : 165E	10S : 125E
10S : 175E	9S : 160E	15S : 120E
15S : 170E	15S : 155E	20S : 118E
20S : 165E	20S : 160E	25S : 115E
25S : 170E		
30S : 180E		

IV. Indian Ocean	V. Pacific Ocean
5S : 80E	5S : 150W
5S : 75E	15S : 160W
10S : 60E	25S : 155W
15S : 55E	30S : 148W
23S : 60E	
30S : 65E	
37S : 75E	


120° 140° 160° 180° 160° 140° 120° 100° 80° 60° 40° 20° 0° 20° 40° 60° 80° 100°
80°N
60°N
40°N
20°N
0°
20°S
40°S
60°S
Greenland
Asia
Asia
North America
Europe
Parallel
Meridian
Equator
Africa
South America
Australia

PROBABLE STUDENT RESULTS



TITLE: **Energy and the Electric Meter**

H. B. Lantz
and Janice Wax
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Orange, Virginia 22960

PURPOSE: To familiarize the students with the electric meter: how to read it, and some implications for energy usage and energy conservation.

MATERIALS: The electric meter at the student's home.

PRE-LAB PREPARATION:

To the student:

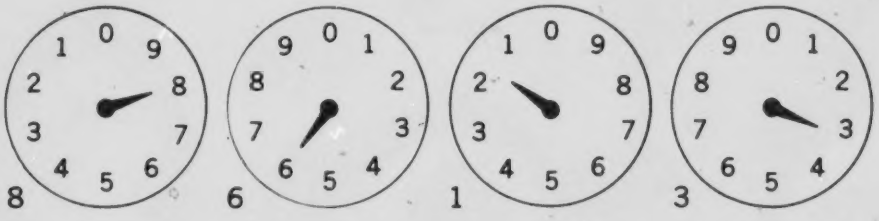
The energy for heat, light, cooling, cooking, washing, playing the stereo, TV, hot water, and numerous other things, is bought, sold, delivered, and charged to us much the same as other retail goods. Instead of the sale being rung up on the cash register, electricity, gas, and water use is registered by meters located near the home. These meters can be read and the cost of energy computed for each day.

On some wall of your home--basement, garage, but most often outside--you'll probably find an intricate glass-enclosed meter. Through the meter's glass enclosure, you should see a revolving aluminum disc and a series of dials and pointers, or digital numbers. Without explanation, they might appear very complex; but they are really quite simple.

The amount of electricity you use in a given time period determines the speed at which the disc rotates. The more electricity you use in a given time period, the faster it turns. Each revolution represents a portion of an electric unit called a watt-hour. This watt-hour measurement is transferred from the disc through a series of gears to the digital numbers or pointers on a dial.

Every hour a hundred-watt light bulb burns, it uses 100 watt-hours of electric energy. Since a watt-hour is such a small unit of energy, your electric utility company uses a unit equal to 1000-watt hours, a kilowatt hours, to measure the amount of electricity used.

Now let's look at the way to read an electric meter. Below you will see a diagram of some dials as they would appear on a kilowatt meter.



Most meters have four dials, though some commercial meters have five. On each dial is a pointer, indicating a number on the dial. To record the meter reading, simply write down the number pointed to on each dial, starting from the left-hand dial and proceeding to the right. In the example, the reading is 8613. If the pointer is registered between two numbers on a dial, always record the smaller number. This is very important.

PROCEDURE: A chart for recording the meter readings for one week is found below:

	DIFFERENCE
1st reading (time, date)_____	
2nd reading (time, date)_____	1st day_____
3rd reading (time, date)_____	2nd day_____
4th reading (time, date)_____	3rd day_____
5th reading (time, date)_____	4th day_____
6th reading (time, date)_____	5th day_____
7th reading (time, date)_____	6th day_____
8th reading (time, date)_____	7th day_____

Total number of kilowatts used during the week_____.

As you can see, a place for entering the date and time of each reading is provided. A reading should be taken every day at the same time in order to get a 24-hour interval.

The first reading is only a starting point, and cannot be used by itself for any comparison. This reading is entered in the space indicated as "first reading". When the second reading is made, the first reading is subtracted from it, the difference being the number of kilowatt hours used during the first day. Enter the difference for each day in the "difference" column. Similarly, when the third reading is made, the second reading is subtracted from it, and so on, always subtracting the previous day's reading from the current reading and recording the difference in the difference column.

CONCLUSIONS: The number of kilowatt-hours will be likely to vary from day to day. It will be interesting to try and account for any variation. Perhaps an increase in electricity on Monday can be attributed to washing and drying of clothes. Find out who in the class used the greatest amount of electricity; who used the least. What is the family size of the larger user?

EXTENSIONS: An interesting extension of this activity might be to extend the activity for one more week, and make it a competitive exercise. The idea of the competition would be to see which family could decrease by the greatest amount the electricity they were using during the next week. A way to show this might be to graph the results and the graph showing the greatest decline would obviously indicate the greatest decline in usage of electricity. However, this extension would have to take into consideration other variables and would need the cooperation of other family members.

Table I

ESTIMATED POWER CONSUMPTION

Household Service	Estimated Kilowatt Hours Annually
Food preparation	3,978
Food preservation	7,867
Laundry	10,346
Comfort conditioning	3,120
Health and beauty	188.3
Home entertainment	1,059
Housewares	89

Table II

ESTIMATED POWER CONSUMED BY HOME APPLIANCES IN ONE YEAR

FOOD PREPARATION	AVERAGE WATTAGE	ESTIMATED KW HOURS CONSUMED ANNUALLY
Blender	306	15
Broiler	1,436	100
Carving Knife	92	8
Coffee Maker	894	106
Deep Fryer	1,448	83
Diswasher	1,201	363
Egg Cooker	516	14
Frying Pan	1,196	186
Hot Plate	1,257	90
Mixer	127	13
Oven, Microwave	1,500	300
Oven, Self-Cleaning	4,800	1,146
Range	8,200	1,175
Roaster	1,333	205
Sandwich Grill	1,161	33
Toaster	1,146	39
Trash Compactor	400	50
Waffle Iron	1,116	22
Waste Disposal	445	30
FOOD PRESERVATION		
Freezer (15 cu. ft.)	341	1,195
Freezer (Frostless, 15 cu. ft.)	440	1,761
Refrigerator (12 cu. ft.)	241	728
Refrigerator (Frostless, 12 cu. ft.)	321	1,217
Refirgerator/Freezer (14 cu. ft.)	326	1,137
(Frostless, 14 cu. ft.)	615	1,829
LAUNDRY		
Clothes Dryer	4,856	993
Iron (Hand)	1,008	144
Washing Machine (Automatic)	512	103
Washing Machine (Non-Automatic)	286	76
Water Heater (Standard)	2,475	4,219
Water Heater (Quick Recovery)	4,474	4,811
COMFORT CONDITIONING		
Air Cleaner	50	216
Air Conditioner	1,566	1,389
Bed Covering	177	147
Dehumidifier	257	377
Fan (Attic)	370	291
Fan (Circulating)	88	43

	AVERAGE WATTAGE	ESTIMATED KW HOURS CONSUMED ANNUALLY
Fan (rollaway)	171	138
Fan (window)	200	170
Heater (portable)	1,322	176
Heating Pad	65	10
Humidifier	177	163
HEALTH & BEAUTY		
Germicidal Lamp	20	141
Hair Dryer	381	14
Heat Lamp (infrared)	250	13
Shaver	14	1.8
Sun Lamp	279	16
Tooth Brush	7	0.5
Vibrator	40	2
HOME ENTERTAINMENT		
Radio	71	86
Radio/Record Player	109	109
Televison (b & w)	237	362
Television (color)	332	502
HOUSEWARES		
Clock	2	17
Floor Polisher	305	15
Sewing Machine	75	11
Vacuum Cleaner	630	46

*The activity and charts have been adapted from the North Caroline Instruction Booklet Environmental Education: Strategies for Wise Use of Energy, February, 1974; "Meter Reading Can Be a Game" by Claxton Walker, The Washington Post; and Robert E. Anderson, State Extension Specialist Environmental Education - WVU Cooperative Extension Service, Morgantown, West Virginia

TITLE: Do Sunspots Affect the Earth's Atmosphere?

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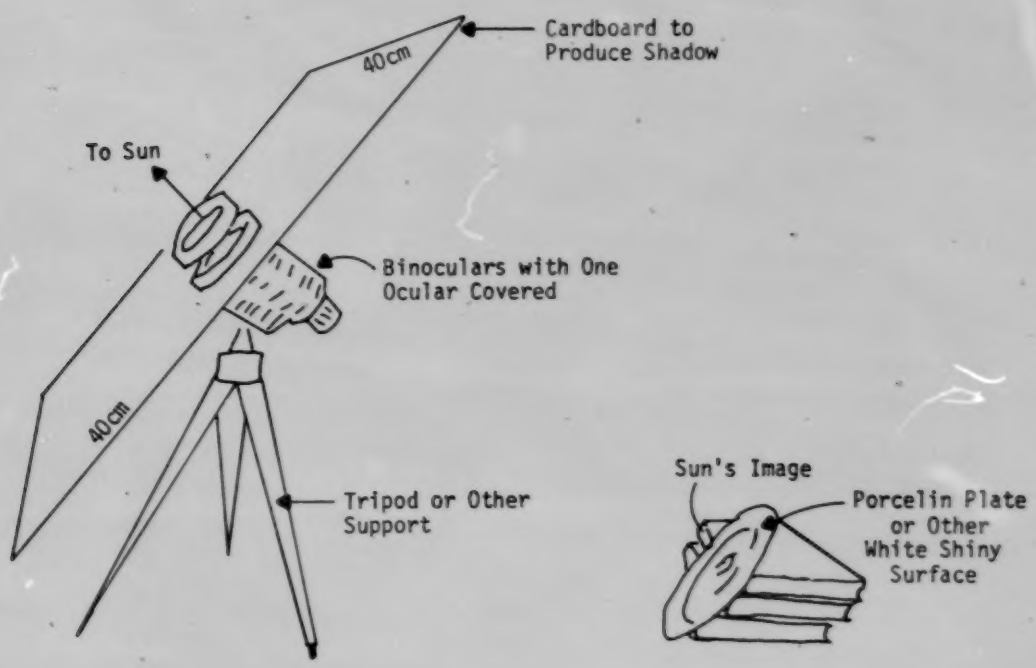
Vienna, Virginia 22150

PURPOSE:
1. To present and graph data on sunspot activity, lightning storms, and length of the growing season.
2. To attempt to observe the images of sunspots.
3. To draw conclusions based upon given data, as to whether sunspots have an effect on the atmosphere.

MATERIALS:
1. sunspot data, lightning storm data, length of growing season data (Tables I, II, III)
2. three sheets of graph paper
3. summary sheet
4. one sunspot viewing apparatus
5. sunspot information which goes back several hundred years (Table II)

PRE-LAB:
1. Note- The data which are presented are controversial and many meteorologists will not support some of the ideas presented by this activity. They are presented here to provide discussion.
2. This activity takes two 55 minute class periods.
3. Run off sets of data.
4. Construct a sunspot viewing apparatus as illustrated below. (Use telescope, monocular or binoculars with one ocular covered)

CAUTION STUDENTS TO NEVER LOOK DIRECTLY AT SUN! THE SUNSPOT VIEWING DEVICE IS DESIGNED TO FOCUS THE SUN'S IMAGE ON A SCREEN.



PROCEDURE: Verbal Instructions

1. Conduct a brief discussion of sunspots.
2. Have students plot sunspot data given in Table I.
3. The next day discuss the following questions:
   a. What is the average time between high points on your graph? (about 10 years)
   b. How many sunspots will there be the year you graduate? (must continue the graph to make predictions)
   c. How many sunspots should be visible today? (again, prediction based on graph).
   d. Have students go outside, set up the apparatus and observe sunspots. DO NOT LOOK DIRECTLY AT THE SUN. Try to make a count of sunspots. If predicted number does not agree with the count, try to explain the difference. Answer: a. poor equipment, b. previous data not accurate, etc,.
   e. Return to the classroom and show the students the data going back several hundred years. Why do predictions have to be revised? Answer: the more complete data show that the 10 year cycle fits into a much longer cycle in which the maximum number of sunspots increases and then decreases. Recently, the maximum has declined to a very low number.
   f. Give the students the data for lightning storms and length of growing season and have them plot these data to the same scale as sunspots.
   g. The next day ask the students if there appears to be a similarity in sunspots, lightning storms, and length of a growing season. Answer: there will probably be a great difference of opinion.
   h. Give out the summary chart. When students have finished ask the same question again. Answer: there appears to be a possible relationship because the maxima and minima agree so closely.

Table I

ANNUAL SUNSPOT NUMBERS, 1906-1965*

YEAR	SUNSPOT NUMBER	YEAR	SUNSPOT NUMBER	YEAR	SUNSPOT NUMBER
1906	53.8	1926	63.9	1946	92.6
1907	62.0	1927	69.0	1947	151.5
1908	48.5	1928	77.8	1948	136.2
1909	43.9	1929	65.0	1949	134.7
1910	18.6	1930	35.7	1950	83.9
1911	5.7	1931	21.2	1951	69.3
1912	3.6	1932	11.1	1952	31.5
1913	1.4	1933	5.7	1953	13.9
1914	9.6	1934	8.7	1954	4.4
1915	47.4	1935	36.1	1955	38.0
1916	57.1	1936	79.7	1956	141.7
1917	103.9	1937	114.4	1957	189.9
1918	80.6	1938	109.6	1958	184.6
1919	63.6	1939	88.8	1959	158.8
1920	37.6	1940	67.8	1960	112.3
1921	26.1	1941	47.5	1961	53.9
1922	14.2	1942	30.6	1962	37.6
1923	5.8	1943	16.3	1963	27.9
1924	16.7	1944	11.0	1964	10.2
1925	44.3	1945	33.2	1965	15.1

* Data from Investigating the Earth, 1976, Houghton Mifflin Company, page 21.

Table II

ANNUAL SUNSPOT NUMBERS, 1749-1966**

YEAR	SUNSPOT NUMBER	YEAR	SUNSPOT NUMBER	YEAR	SUNSPOT NUMBER	YEAR	SUNSPOT NUMBER
1749	80.9	1797	6.4	1845	40.1	1893	84.9
1750	83.4	1798	4.1	1846	61.5	1894	78.0
1751	47.7	1799	6.8	1847	98.5	1895	64.0
1752	47.8	1800	14.5	1848	124.3	1896	41.8
1753	30.7	1801	34.0	1849	95.9	1897	26.2
1754	12.2	1802	45.0	1850	66.5	1898	26.7
1755	9.6	1803	43.1	1851	64.5	1899	12.1
1756	10.2	1804	47.5	1852	54.2	1900	9.5
1757	32.4	1805	42.2	1853	39.0	1901	2.7
1758	47.6	1806	28.1	1854	20.6	1902	5.0
1759	54.0	1807	10.1	1855	6.7	1903	24.4
1760	62.9	1808	8.1	1856	4.3	1904	42.0
1761	85.9	1809	2.5	1857	22.8	1905	63.5
1762	61.2	1810	0.0	1858	54.8	1906	53.8
1763	45.1	1811	1.4	1859	93.8	1907	62.0
1764	36.4	1812	5.0	1860	95.7	1908	48.5
1765	20.9	1813	12.2	1861	77.2	1909	43.9
1766	11.4	1814	13.9	1862	59.1	1910	18.6
1767	37.8	1815	35.4	1863	44.0	1911	5.7
1768	69.8	1816	45.8	1864	47.0	1912	3.6
1769	106.1	1817	41.1	1865	30.5	1913	1.4
1770	100.8	1818	30.4	1866	16.3	1914	9.6
1771	81.6	1819	23.9	1867	7.3	1915	47.4
1772	66.5	1820	15.7	1868	37.3	1916	57.1
1773	34.8	1821	6.6	1869	73.9	1917	103.9
1774	30.6	1822	4.0	1870	139.1	1918	80.6
1775	7.0	1823	1.8	1871	111.2	1919	63.6
1776	19.8	1824	8.5	1872	101.7	1920	37.6
1777	92.5	1825	16.6	1873	66.3	1921	26.1
1778	154.4	1826	36.3	1874	44.7	1922	14.2
1779	125.9	1827	49.7	1875	17.1	1923	5.8
1780	84.8	1828	62.5	1876	11.3	1924	16.7
1781	68.1	1829	67.0	1877	12.3	1925	44.3
1782	38.5	1830	71.0	1878	3.4	1926	63.9
1783	22.8	1831	47.8	1879	6.0	1927	69.0
1784	10.2	1832	27.5	1880	32.3	1928	77.8
1785	24.1	1833	8.5	1881	54.3	1929	65.0
1786	82.9	1834	13.2	1882	59.7	1930	35.7
1787	132.0	1835	56.9	1883	63.7	1931	21.2
1788	130.9	1836	121.5	1884	63.5	1932	11.1
1789	118.1	1837	138.3	1885	52.2	1933	5.7
1790	89.9	1838	103.2	1886	25.4	1934	8.7
1791	66.6	1839	85.8	1887	13.1	1935	36.1
1792	60.0	1840	63.2	1888	6.8	1936	79.7
1793	46.9	1841	36.8	1889	6.3	1937	114.4
1794	41.0	1842	24.2	1890	7.1	1938	109.6
1795	21.3	1843	10.7	1891	35.6	1939	88.8
1796	16.0	1844	15.0	1892	73.0	1940	67.8

Table II (cont'd)

YEAR	SUNSPOT NUMBER	YEAR	SUNSPOT NUMBER	YEAR	SUNSPOT NUMBER	YEAR	SUNSPOT NUMBER
1941	47.5	1948	136.2	1955	38.0	1962	37.6
1942	30.6	1949	134.7	1956	141.7	1963	27.9
1943	16.3	1950	83.9	1957	189.9	1964	10.2
1944	11.0	1951	69.3	1958	184.6	1965	15.1
1945	33.2	1952	31.5	1959	158.8	1966	47.0
1946	92.6	1953	13.9	1960	112.3		
1947	151.5	1954	4.4	1961	53.9		

**Data from Investigating The Earth Teacher's Guide Part I, 1967, Houghton Mifflin Company, page 47.

Table III

Length of the growing season in days in Eskelemuir, Scotland (55 N, 30 W)

YEAR	LENGTH IN DAYS	YEAR	LENGTH IN DAYS	YEAR	LENGTH IN DAYS
1915	198	1936	205	1957	221
1916	194	1937	210	1958	223
1917	195	1938	215	1959	235
1918	198	1939	217	1960	227
1919	196	1940	216	1961	228
1920	193	1941	208	1962	227
1921	190	1942	205	1963	218
1922	188	1943	218	1964	212
1923	191	1944	219	1965	205
1924	186	1945	221	1966	204
1925	187	1946	223	1967	205
1926	188	1947	224	1968	206
1927	195	1948	225	1969	208
1928	197	1949	209	1970	209
1929	202	1950	208	1971	?
1930	197	1951	200	1972	?
1931	198	1952	205	1973	?
1932	199	1953	203	1974	?
1933	190	1954	206	1975	?
1934	189	1955	212	1976	?
1935	194	1956	212		

Table IV

The following data represents the number of lightning flashes in an area of Britain from 1933 to 1973.***

Year	Number of Flashes
1933	97
1934	108
1935	110
1936	107
1937	118
1938	110
1939	91
1940	86
1941	82
1942	70
1943	67
1944	71
1945	90
1946	94
1947	99
1948	102
1949	83
1950	80
1951	74
1952	63
1953	62
1954	78
1955	91
1956	100
1957	109
1958	118
1959	120
1960	110
1961	97
1962	91
1963	82
1964	71
1965	80
1966	74
1967	100
1968	110
1969	93
1970	77
1971	74
1972	68
1973	67

Directions

1. Plot the data on a graph.
2. Label all parts of the graph.

Answer the following questions on the back of your graph.

1. Do you think that there is probably a relationship between sunspots and lightning storms?
2. Explain your answer to the class.
3. What will be the approximate number of lightning flashes in:
   1978 ?
   1984 ?

***After - Dr. M. F. Stringfellow, Nature.

Place the three graphs (sunspot cycle, lightning flashes, and length of growing season) on your desk.

Fill in the following charts.

Year when maximum (high) numbers occurred

Sunspots	1907	1917	_____	_____	_____	_____	_____
Growing		1918	_____	_____	_____	_____	_____
Lightning				1937	_____	_____	_____

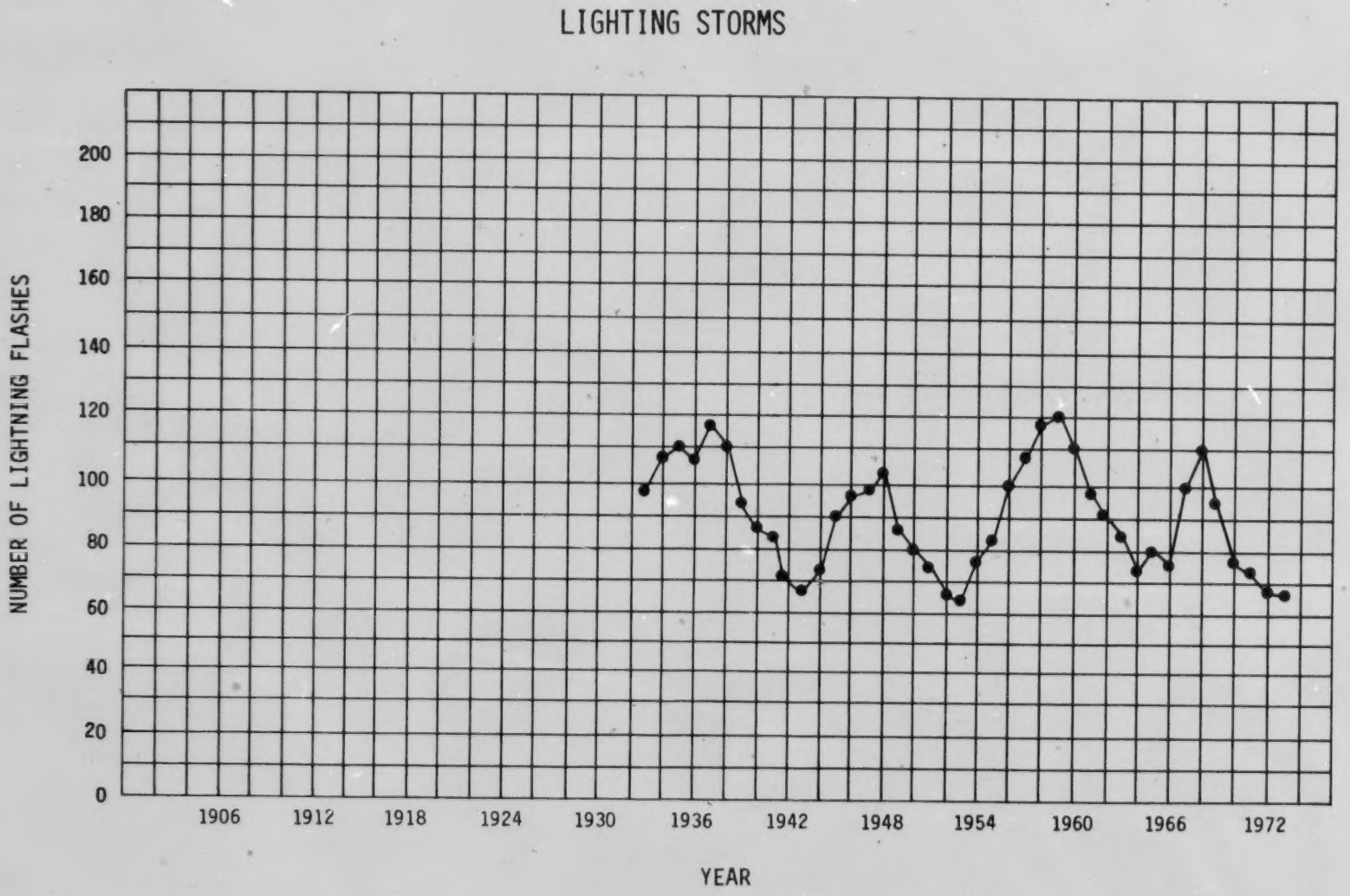
Year when minimum (low) numbers occurred

Sunspots	_____	_____	_____	_____	_____	_____	_____
Growing		_____	_____	_____	_____	_____	_____
Lightning				_____	_____	_____	_____

1. Do you think that there is a relationship between sunspots and lightning storms based on the data_____? Explain!

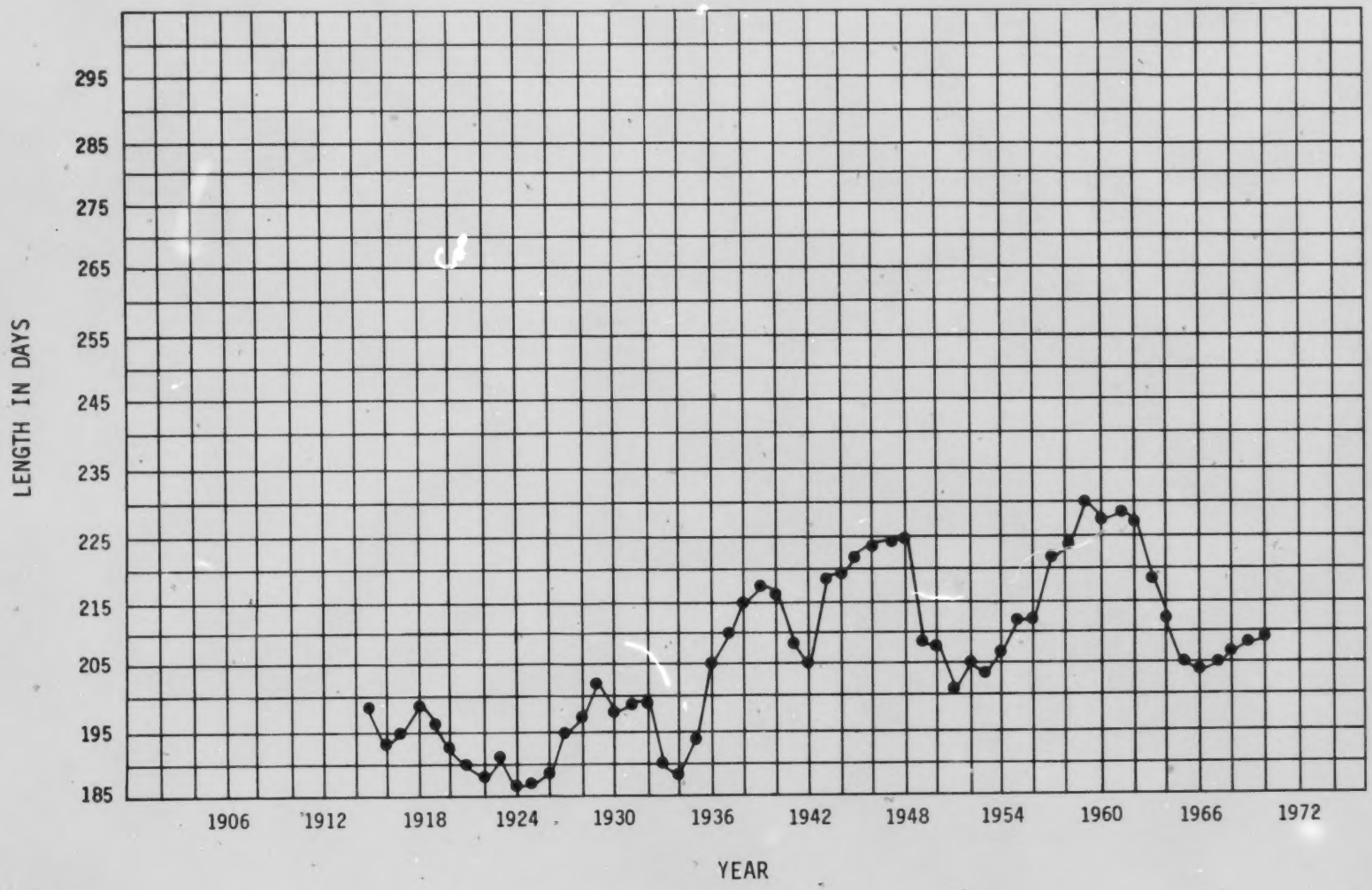
2. Do you think that there is a relationship between sunspots and the length of growing season based on the data_____? Explain!

M-4-9


LIGHTING STORMS
NUMBER OF LIGHTNING FLASHES
200
180
160
140
120
100
80
60
40
20
0
1906
1912
1918
1924
1930
1936
1942
1948
1954
1960
1966
1972
YEAR

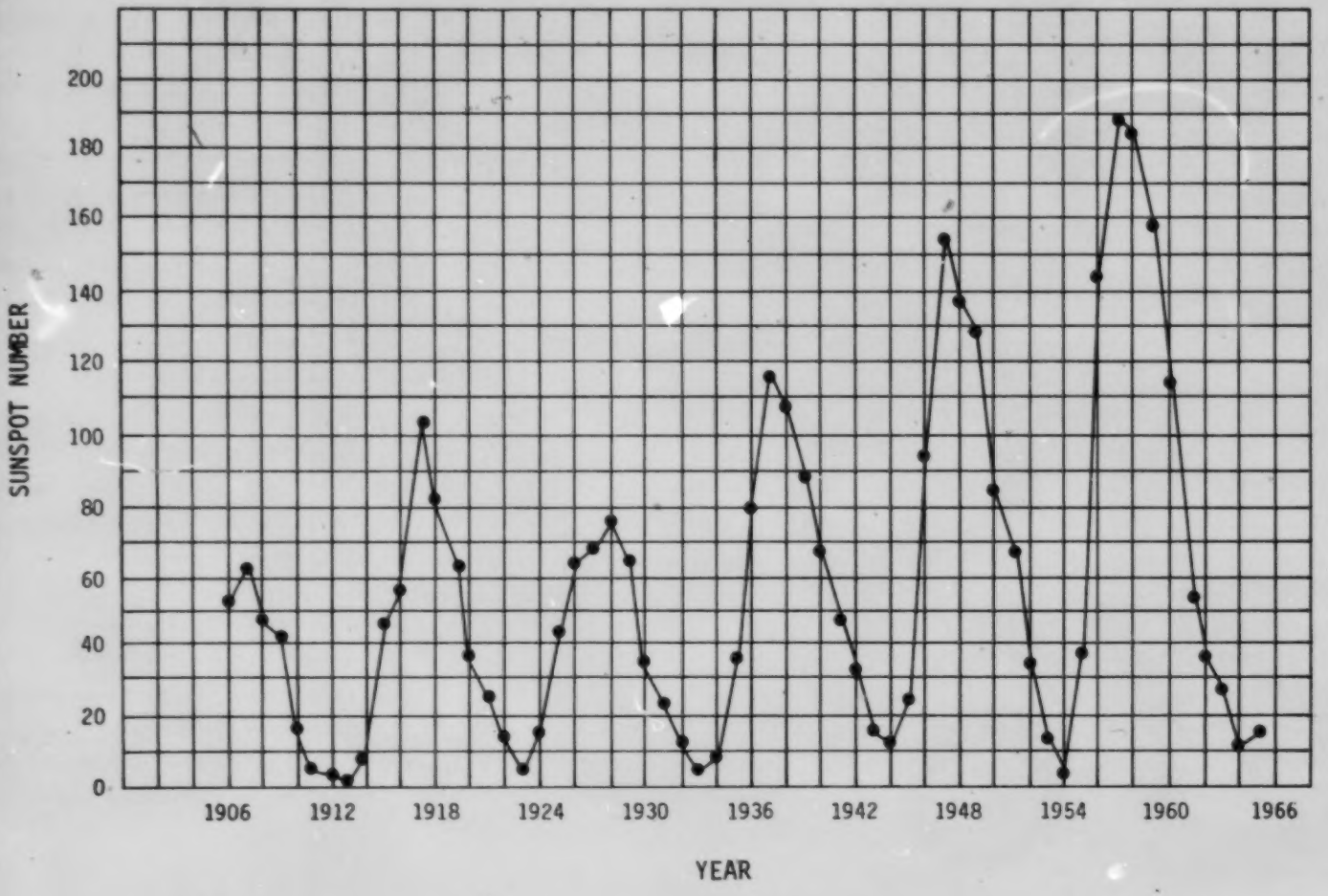
M-4-10

LENGTH OF GROWING SEASON - 1915-1970



DATA FROM TABLE I:

ANNUAL SUNSPOT NUMBER - 1906-1965



Answer sheet-

Place the three graphs (sunspot cycle, lightning flashes, and length of growing season) on your desk.

Fill in the following charts.

Year when maximum (high) numbers occurred

Sunspots	1907	1917	1927	1937	1947	1957	_____
Growing		1918	1929	1939	1948	1959	_____
Lightning			_____	1937	1948	1959	1968

Year when minimum (low) numbers occurred

Sunspots	1913	1923	1933	1944	1954	1964
Growing		1924	1934	1942	1951	1966
Lightning				1943	1953	1964

1. Do you think that there is a relationship between sunspots and lightning storms based on the data? _____Explain!
   Lightning storms had maxima 1 to 2 years after every sunspot maximum and minima near every sunspot minimum. Also, as the maxima and minima increased in the sunspot cycle so did lightning storms.

2. Do you think that there is a relationship between sunspots and the length of growing season? _____Explain!
   Yes- The growing season maxima and minima were always within a few years of the sunspot maxima and minima.

TITLE: Meteorology Laboratory: Water Budget

Ann Dorr
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John Kline
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PURPOSE:

1. Each student should compute a water budget for a city of his choice. (Data pages M-5-4 to M-5-10)
2. Each student should make a water budget graph of the data which were computed.
3. Each student should construct a climate map from all the water budgets which were computed.

MATERIALS:

1. water budget data (P and PE) for various cities in North America - (Pages M-5-4 to M-5-10)
2. water budget graphs (included)
3. one large map of United States and Southern Canada, (This map should be drawn on the bulletin board as large as possible.)
4. small individual outline maps of the United States and Southern Canada
5. United States Atlas
6. water budget instructions (included)
7. graph paper

PRE-LAB PREPARATION:

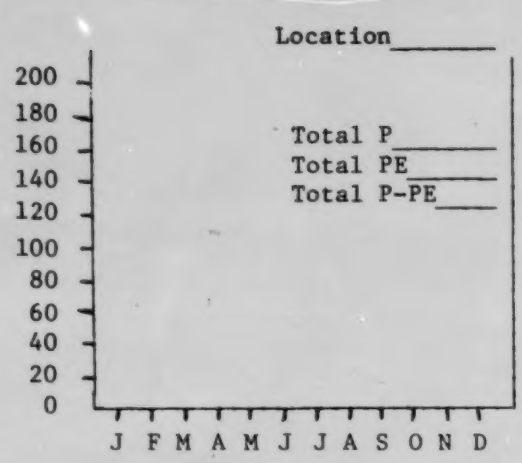
1. Students must be familiar with computing water budgets as described in Chapter Nine (Investigation 9-9) ESCP 1967 version. Detailed instructions are included at the end of this activity.
2. A large outline map of the United States should be drawn on the bulletin board. This map should have the states outlined but as little detail as possible.
3. Small water budget graphs should be reproduced, one for each student.
4. Individual outline maps of the U.S. should be reproduced, one for each student.
5. Have a U.S. Atlas handy for students to look up the locations of the cities. This activity is a good summary which should come near the end of a study of weather and climate (Chapter 11 ESCP). Students compute water budgets for a city which they choose. They should make water budget graphs and place these graphs on the large map at the appropriate locations. When all data have been posted the students can plot the data on their individual maps and make: 1) precipitation 2) potential evapotranspiration or 3) P-PE maps of North America. If the school has computer courses and a computer is available a computer program can be developed to calculate the water budgets for the students. Each student can type in the P and PE data with proper supervision and let the computer make the calculations.
6. Activity takes about two 55 minute class periods.

Procedure: All instructions should be verbal.

A. Have each student select a city from the list. Encourage them to select a place where they have lived or visited or one in which they have special interest. When a city has been selected mark it off so that the same city is not selected more than once and try to get a good distribution of cities. How this is accomplished might be determined by the number of students involved. If there are several (3 or more) classes the continent will probably be well covered. If only one class is involved you may want to put the location data numbers in a hat representing a good distribution and let students draw out the number for a city. Students should compute the water budget, and graph it. Then write the data for total P, total PE and total P-PE on the graph in the appropriate places. This part should be completed for homework.

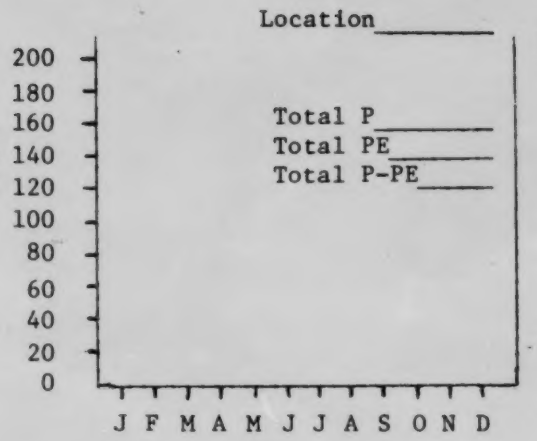
B. On the following day the students should staple their water budget graphs to the bulletin board map in the appropriate places. Use about 30 minutes for discussing the results. The following questions should be answered:
   1. How do the water budget graphs change when you compare water budgets on the same parallel East to West? Answer: As one moves westward the general trend is for similar PE curves but with much greater moistures deficits.
   2. How do the water budget graphs differ when you compare water budgets on the same meridian of longitude North to South? Answer: The moisture deficits usually don't change much but the PE becomes less as you move northward.
   3. In what parts of the country do the water budget graphs not fit the general patterns described in questions 1 and 2? Answer: Especially the northwest coast (Oregon, Washington and California) do not fit the general trend largely because of high mountains which cause greater precipitation and the influence of the cold coastal currents.

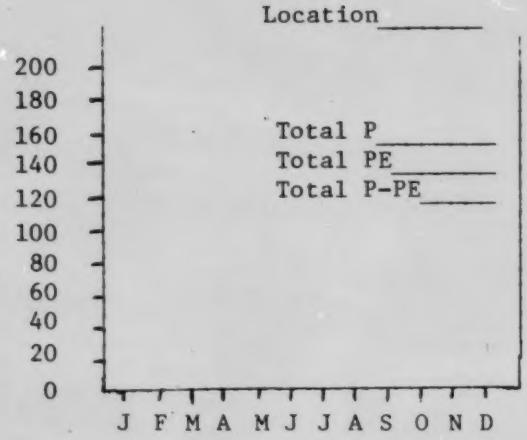
C. Continue by having students discuss the different kinds of maps that could be constructed from these data. Usually the discussion will center around:
   1. Precipitation - If the total annual precipitation for each city is written on a map at its appropriate place, isolines can be drawn and different precipitation zones colored in.
   2. Potential Evapotranspiration - If the total annual PE for each city is written on a map at its appropriate place, isolines will illustrate need patterns for water. This will be very similar to a temperature map since the PE need is based primarily on average temperatures.
   3. Other kinds of maps using other parts of data could be constructed.

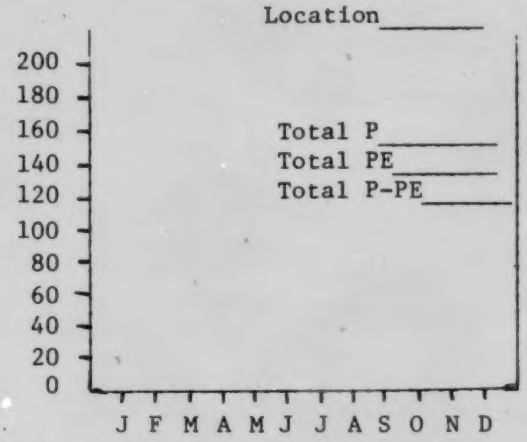


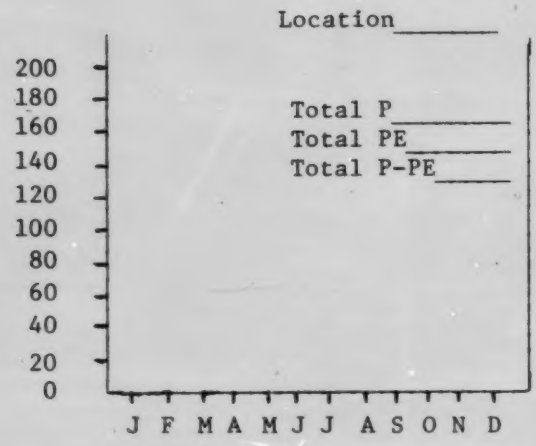
For each of the locations plot:

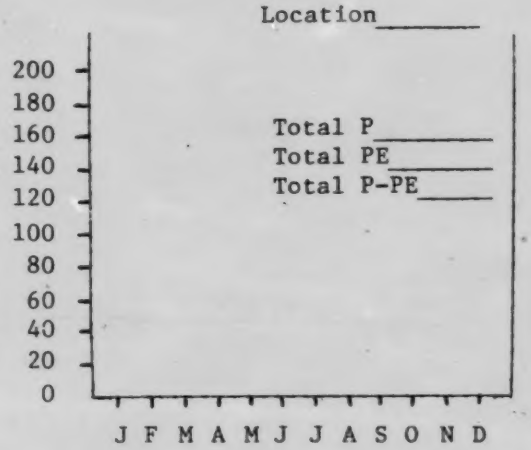
P
PE
P-PE











WATER BUDGET DATA*

United States		J	F	M	A	M	J	J	A	S	O	N	D	Yr
Phoenix,	PE	13	21	40	75	129	189	211	193	158	84	31	13	1157
Arizona	P	21	19	17	10	3	2	25	27	19	12	15	21	191
Tucson,	PE	16	21	37	65	114	170	192	176	142	79	32	16	1060
Arizona	P	21	22	19	10	5	7	56	55	29	14	20	25	283
Fort Smith,	PE	5	8	31	62	109	152	181	167	117	64	23	8	927
Arkansas	P	61	68	36	43	223	45	264	41	42	45	15	143	1026
Little Rock,	PE	8	10	31	65	112	151	176	160	114	64	23	10	924
Arkansas	P	125	102	118	128	127	94	85	84	80	72	104	104	1223
Fresno,	PE	13	20	37	63	99	139	180	165	114	70	31	12	943
California	P	44	40	41	24	10	3	0	0	4	13	22	40	241
Los Angeles,	PE	34	36	49	59	76	94	117	115	96	73	52	39	840
California	P	78	79	66	27	9	2	0	1	5	14	29	68	378
San Francisco,	PE	31	35	49	59	70	78	79	77	75	66	48	35	702
California	P	119	93	77	39	17	4	0	1	7	24	59	111	551
Denver,	PE	0	0	12	37	74	112	141	127	81	43	12	2	641
Colorado	P	12	14	28	52	62	36	42	36	26	26	16	16	366
Grand Junction,	PE	0	0	19	47	89	134	163	138	94	46	10	0	740
Colorado	P	15	16	20	19	18	10	15	28	23	22	15	14	215
Hartford,	PE	0	0	9	37	83	118	142	125	84	46	15	0	659
Connecticut	P	91	81	94	94	89	89	95	102	89	78	94	91	1087
New London,	PE	0	0	9	37	79	113	136	123	87	51	19	1	655
Connecticut	P	99	95	102	93	86	79	91	107	84	92	98	93	1119
Milford,	PE	3	3	22	48	92	129	154	137	99	55	25	6	773
Delaware	P	91	89	100	91	91	94	114	115	85	81	75	93	1119
Wilmington,	PE	0	0	15	43	89	128	152	135	94	52	20	2	730
Delaware	P	87	80	96	91	92	98	119	128	93	78	82	86	1130
Miami,	PE	47	50	74	103	136	162	172	168	147	116	76	57	1308
Florida	P	49	43	54	109	155	194	202	182	235	206	73	45	1547
Orlando,	PE	33	39	59	90	140	167	175	173	142	100	53	35	1206
Florida	P	50	56	91	88	81	161	230	180	200	121	39	45	1342
Albany,	PE	15	19	45	76	124	165	177	166	129	73	26	17	1032
Georgia	P	108	131	125	95	96	115	155	142	88	61	60	99	1275
Atlanta,	PE	11	13	31	62	108	144	157	146	111	61	26	10	880
Georgia	P	120	119	139	101	88	96	119	103	82	64	77	113	1221
Honolulu,	PE	68	65	77	87	105	118	129	130	118	108	86	76	1167
Hawaii	P	87	102	81	53	35	21	26	31	37	45	86	99	703
Boise,	PE	0	5	21	47	80	112	152	133	81	46	12	0	689
Idaho	P	37	35	34	30	33	23	6	5	12	26	33	34	308

*From Earth Science Curriculum Project (1967 Blue Version) Appendix G.

United States		J	F	M	A	M	J	J	A	S	O	N	D	Yr
Pocatello,	PE	0	0	12	40	72	107	142	125	87	40	10	0	635
Idaho	P	32	27	31	33	34	26	17	18	21	26	24	27	316
Chicago,	PE	0	0	6	37	79	122	146	132	90	51	12	0	675
Illinois	P	49	48	68	74	90	93	84	80	76	67	59	50	838
Springfield,	PE	0	0	12	47	93	139	160	138	94	52	12	0	747
Illinois	P	52	54	77	88	107	106	78	74	85	68	62	51	902
Evansville,	PE	0	3	15	46	92	141	169	144	100	49	15	2	776
Indiana	P	98	82	105	99	101	101	85	82	80	70	88	85	1076
Indianapolis,	PE	0	0	12	47	93	135	152	135	94	49	12	0	729
Indiana	P	77	65	96	93	100	107	95	82	82	69	82	73	1021
Davenport,	PE	0	0	7	44	89	130	152	132	89	46	9	0	698
Iowa	P	39	39	59	73	97	108	88	90	89	61	48	38	829
Des Moines,	PE	0	0	6	44	91	130	157	136	90	46	10	0	710
Iowa	P	29	29	48	70	110	95	85	92	84	60	40	30	772
Garden City,	PE	0	1	19	48	90	133	160	147	99	49	13	0	759
Kansas	P	8	23	24	53	64	80	75	55	47	32	18	17	496
Wichita,	PE	0	0	15	53	92	145	172	158	103	55	15	0	808
Kansas	P	21	30	45	74	110	114	85	77	79	61	38	26	760
Bowling Green,	PE	3	5	27	57	104	145	165	150	106	56	20	5	843
Kentucky	P	122	101	130	114	112	99	106	92	81	75	100	107	1239
Lexington,	PE	0	3	19	50	92	134	150	137	103	40	18	2	748
Kentucky	P	112	83	113	90	94	107	84	85	70	61	82	91	1072
Alexandria,	PE	15	18	45	75	122	164	179	170	129	69	31	15	1032
Louisiana	P	127	133	142	134	119	115	136	106	73	85	111	152	1433
New Orleans,	PE	22	26	49	84	127	168	180	171	139	88	40	24	1118
Louisiana	P	115	117	139	135	124	147	177	153	140	85	92	119	1543
Bangor,	PE	0	0	0	37	84	120	145	127	81	45	12	0	651
Maine	P	81	67	73	88	79	82	67	67	92	85	104	79	964
Portland,	PE	0	0	0	30	69	108	133	115	78	43	17	0	593
Maine	P	101	105	101	88	87	82	80	77	82	82	96	96	1077
Baltimore,	PE	0	3	19	50	96	134	163	142	59	55	20	5	746
Maryland	P	86	81	95	90	93	97	113	114	90	77	72	80	1088
Cumberland,	PE	0	1	13	48	93	128	145	126	89	48	15	2	708
Maryland	P	62	64	75	72	84	102	82	88	69	61	54	64	877
Boston,	PE	0	0	9	37	79	118	142	125	87	51	20	0	668
Massachusetts	P	93	84	98	91	83	81	84	94	81	84	97	88	1058

United States		J	F	M	A	M	J	J	A	S	O	N	D	Yr
Pittsfield,	PE	0	0	0	29	77	109	128	112	75	40	9	0	579
Massachusetts	P	79	64	81	91	97	117	127	109	107	74	101	76	1123
Lansing,	PE	0	0	0	34	76	119	135	122	81	46	10	0	623
Michigan	P	46	44	62	71	93	84	70	73	73	65	57	48	786
Sault Ste. Marie,	PE	0	0	0	20	66	101	123	110	75	37	0	0	532
Michigan	P	50	36	44	55	69	75	68	72	91	75	77	57	769
Duluth,	PE	0	0	0	24	66	98	127	113	75	37	0	0	540
Minnesota	P	27	25	39	54	79	103	95	84	80	53	41	27	707
Minneapolis-	PE	0	0	0	37	88	124	149	127	81	39	0	0	645
St. Paul, Minn.	P	20	22	37	52	85	107	89	83	74	49	34	23	675
Jackson,	PE	16	21	40	71	118	159	178	166	124	71	29	15	1008
Mississippi	P	124	124	140	132	112	104	114	88	64	54	91	135	1282
Tupelo,	PE	9	12	34	64	108	152	168	158	115	60	24	10	914
Mississippi	P	114	108	153	116	120	98	98	99	81	65	98	134	1284
Kansas City,	PE	0	0	15	53	96	141	170	152	100	55	15	0	797
Missouri	P	35	39	65	85	94	95	94	100	103	72	47	36	865
St. Louis,	PE	0	0	19	53	100	145	170	152	100	55	18	2	814
Missouri	P	57	60	83	94	105	106	83	76	80	69	67	54	934
Great Falls,	PE	0	0	0	34	74	103	140	121	76	42	7	0	597
Montana	P	17	20	23	26	60	76	33	27	32	19	21	14	368
Miles City,	PE	0	0	0	34	81	113	154	135	78	39	0	0	634
Montana	P	10	10	15	27	50	80	36	33	27	23	11	8	330
Missoula,	PE	0	0	9	41	74	103	136	117	72	33	2	0	587
Montana	P	25	22	22	26	47	51	24	21	31	27	28	28	352
Lincoln,	PE	0	0	0	47	90	136	164	143	94	49	10	0	742
Nebraska	P	19	25	36	63	97	110	92	88	74	46	30	21	701
Scottsbluff,	PE	0	0	9	40	79	118	146	129	81	40	7	0	649
Nebraska	P	9	12	22	47	70	70	45	34	34	23	12	12	390
Las Vegas,	PE	5	10	31	69	123	183	208	195	139	67	21	76	1127
Nevada	P	14	9	11	6	2	1	13	12	9	7	8	10	102
Reno,	PE	0	7	22	40	71	101	130	117	78	43	17	2	628
Nevada	P	35	28	20	12	15	9	7	6	7	11	16	27	193
Hanover,	PE	0	0	0	30	77	112	134	113	76	39	6	0	587
New Hampshire	P	69	58	66	66	79	86	89	89	81	79	71	66	899
Manchester,	PE	0	0	0	31	81	118	135	120	79	41	12	0	617
New Hampshire	P	84	76	91	81	79	81	86	86	86	76	84	81	991
New Brunswick,	PE	0	0	12	42	86	123	145	126	90	50	18	1	693
New Jersey	P	93	91	92	94	98	96	129	131	92	91	85	91	1183

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WATER BUDGET DATA

United States		J	F	M	A	M	J	J	A	S	O	N	D	Yr
Vineland,	PE	0	1	14	43	90	128	154	133	93	51	18	2	727
New Jersey	P	100	93	99	86	91	89	118	120	91	82	79	96	1144
Albuquerque,	PE	3	8	25	52	91	134	151	136	96	52	15	3	766
New Mexico	P	9	9	10	15	17	15	36	33	23	21	11	11	210
Carlsbad,	PE	11	15	38	66	112	155	169	156	109	61	25	8	925
New Mexico	P	8	9	14	20	19	45	61	48	43	36	14	14	331
Buffalo,	PE	0	0	0	30	72	111	135	122	84	48	15	0	617
New York	P	81	72	71	68	73	69	73	74	75	78	80	81	895
New York,	PE	0	0	12	40	86	125	149	132	94	55	22	2	717
New York	P	89	86	98	86	84	85	106	113	88	88	82	85	1090
Syracuse,	PE	0	0	3	34	83	115	134	122	84	46	15	0	636
New York	P	72	68	81	75	74	87	84	82	72	76	68	72	911
Asheville,	PE	8	10	28	56	91	124	138	125	93	52	23	10	758
North Caroline	P	72	72	93	78	80	94	85	96	74	68	51	75	938
Raleigh,	PE	8	10	28	59	105	143	167	143	102	58	26	10	859
North Carolina	P	86	95	94	88	99	109	142	138	97	74	63	83	1168
Bismarck,	PE	0	0	0	31	78	115	144	124	72	31	0	0	595
North Dakota	P	12	12	23	37	57	86	56	46	33	24	15	13	414
Grand Forks,	PE	0	0	0	31	80	116	134	116	71	30	0	0	578
North Dakota	P	14	15	19	47	66	87	69	63	47	32	21	16	496
Cincinnati,	PE	0	2	17	50	102	134	155	138	97	51	17	3	766
Ohio	P	80	76	89	82	100	106	97	90	73	65	83	84	1025
Cleveland,	PE	0	0	6	37	83	121	141	125	90	49	15	0	667
Ohio	P	66	61	73	70	80	83	86	75	79	67	66	60	866
Boise City,	PE	0	4	18	45	85	132	155	136	91	47	14	0	727
Oklahoma	P	13	19	26	47	78	79	83	74	53	55	26	15	568
Oklahoma City,	PE	3	5	25	59	102	149	177	167	114	61	21	5	888
Oklahoma	P	34	31	53	85	132	101	70	69	77	72	48	38	810
Burns,	PE	0	0	12	40	72	97	136	115	75	40	7	0	594
Oregon	P	41	35	25	18	24	23	10	9	14	23	33	39	294
Medford,	PE	10	17	31	50	83	107	138	125	87	48	20	9	725
Oregon	P	70	56	40	30	32	24	6	5	17	42	66	77	465
Portland,	PE	9	17	34	54	81	101	123	113	81	54	26	13	706
Oregon	P	162	132	115	70	54	41	13	17	46	87	158	177	1072
Harrisburg,	PE	0	0	15	43	93	128	149	131	94	52	17	0	722
Pennsylvania	P	73	67	80	76	92	89	92	97	77	74	63	71	951
Pittsburgh,	PE	0	0	12	43	93	131	149	131	94	49	15	2	719
Pennsylvania	P	75	64	82	78	85	97	103	82	65	64	59	69	923

WATER BUDGET DATA

United States		J	F	M	A	M	J	J	A	S	O	N	D	Yr
Kingston,	PE	0	0	6	33	75	108	130	119	83	48	17	0	617
Rhode Island	P	122	109	119	117	99	89	84	109	99	101	107	117	1272
Providence,	PE	0	0	12	37	79	118	142	125	87	48	17	0	665
Rhode Island	P	93	80	93	90	77	74	81	94	81	75	90	90	1018
Charleston,	PE	18	21	40	72	118	157	174	159	121	73	34	21	1008
South Carolina	P	74	83	89	71	85	121	183	167	133	81	57	72	1216
Columbia,	PE	13	15	37	65	115	158	172	157	114	64	29	13	952
South Carolina	P	76	95	91	80	78	99	141	139	98	61	73	77	1108
Rapid City,	PE	0	0	3	34	76	112	144	126	78	40	7	0	620
South Dakota	P	11	11	25	49	83	84	59	41	33	25	16	13	450
Sioux Falls,	PE	0	0	0	40	88	128	152	130	81	43	2	0	664
South Dakota	P	16	20	35	63	93	112	78	81	66	38	26	19	647
Knoxville,	PE	5	8	28	59	102	143	156	143	102	55	21	76	898
Tennessee	P	117	117	129	106	95	102	113	96	71	66	84	110	1206
Memphis,	PE	5	10	31	65	113	152	173	160	114	64	26	10	923
Tennessee	P	134	112	131	126	106	94	84	80	72	72	107	114	1232
Brownsville,	PE	30	37	65	103	150	172	179	171	147	101	55	33	1243
Texas	P	34	35	29	36	62	69	46	65	138	84	47	41	686
Dallas,	PE	8	15	34	72	118	171	192	183	130	73	29	10	1035
Texas	P	59	57	71	106	126	83	46	57	65	76	68	65	879
San Antonio,	PE	16	23	46	84	127	168	187	178	136	85	37	21	1108
Texas	P	39	41	44	77	82	70	52	57	78	60	43	43	686
Cedar City,	PE	0	0	16	42	76	117	148	131	82	40	9	0	661
Utah	P	23	29	36	34	22	11	36	36	26	35	29	23	340
Salt Lake City,	PE	0	0	15	40	79	121	160	143	90	46	12	0	706
Utah	P	34	34	47	49	45	22	14	22	21	36	35	34	393
Burlington,	PE	0	0	0	30	80	116	148	119	78	43	7	0	621
Vermont	P	46	43	54	61	76	89	92	85	86	75	68	50	825
Rutland,	PE	0	0	0	28	75	114	133	114	78	41	8	0	591
Vermont	P	57	48	63	74	80	90	86	86	92	94	88	56	914
Newport News,	PE	8	7	26	53	88	133	155	143	103	62	26	9	813
Virginia	P	79	92	106	83	98	122	159	147	72	71	55	92	1176
Roanoke,	PE	5	8	19	63	99	133	154	137	93	52	20	5	788
Virginia	P	72	87	90	84	99	93	85	109	82	73	60	81	1015
Seattle,	PE	14	19	31	51	79	100	117	107	76	47	25	17	683
Washington	P	124	94	76	55	43	35	15	18	42	75	130	133	840
Spokane,	PE	0	0	0	44	83	108	141	125	76	39	9	0	625
Washington	P	53	41	33	27	34	33	13	15	22	33	51	55	410

WATER BUDGET DATA

United States		J	F	M	A	M	J	J	A	S	O	N	D	Yr
Charleston,	PE	5	5	25	56	96	130	150	137	100	55	20	5	784
West Virginia	P	101	87	105	95	96	102	127	106	74	70	76	84	1123
Parkersburg,	PE	0	3	19	50	96	130	151	135	94	52	18	2	750
West Virginia	P	87	73	90	80	88	108	109	94	69	59	64	73	994
Madison,	PE	0	0	0	40	83	123	143	126	81	46	5	0	647
Wisconsin	P	34	27	48	70	89	110	102	86	74	56	51	35	782
Wausau,	PE	0	0	0	32	79	114	134	114	75	37	0	0	585
Wisconsin	P	27	27	45	67	92	106	104	93	94	70	42	28	795
Casper,	PE	0	0	0	30	72	108	139	126	78	40	2	0	595
Wyoming	P	13	13	24	37	50	31	23	17	22	22	18	11	281
Sheridan,	PE	0	0	0	34	73	104	141	123	72	34	2	0	583
Wyoming	P	19	17	32	54	67	59	33	21	35	32	20	17	406

Canada		J	F	M	A	M	J	J	A	S	O	N	D	Yr
Calgary,	PE	0	0	0	31	76	99	123	105	63	31	0	0	528
Alberta	P	13	14	21	25	59	80	64	58	38	18	18	15	423
Edmonton,	PE	0	0	0	31	80	106	123	103	60	29	0	0	532
Alberta	P	22	16	19	22	47	78	84	60	34	19	19	21	441
Prince George,	PE	0	0	0	32	73	102	116	104	61	29	0	0	517
British Columbia	P	46	31	37	21	34	52	41	49	51	51	47	47	507
Vancouver,	PE	6	13	27	48	77	103	119	104	70	44	21	11	643
British Columbia	P	218	147	128	85	72	62	31	43	92	147	210	222	1457
Winnipeg,	PE	0	0	0	21	78	120	137	115	68	26	0	0	565
Manitoba	P	23	22	30	35	57	80	78	62	60	38	28	24	537
Edmundston,	PE	0	0	0	18	66	107	124	109	69	33	0	0	526
New Brunswick	P	74	55	46	51	76	100	105	85	89	72	77	63	893
Saint John,	PE	0	0	0	25	64	93	110	104	75	43	10	0	524
New Brunswick	P	109	78	92	82	80	80	77	92	90	102	97	97	1076
Grand Falls,	PE	0	0	0	9	53	92	126	109	73	35	8	0	505
Newfoundland	P	65	84	67	48	60	84	75	88	91	127	124	100	1013
St. John's,	PE	0	0	0	15	50	85	114	108	72	43	17	0	504
Newfoundland	P	135	130	118	96	98	80	80	101	95	121	145	151	1350
Norman Wells,	PE	0	0	0	0	53	111	126	96	46	0	0	0	432
Northwest Terrs.	P	17	15	9	14	17	36	51	67	42	20	21	17	326
Halifax,	PE	0	0	0	29	70	102	126	116	83	51	18	0	595
Nova Scotia	P	141	110	121	115	104	103	95	114	102	134	135	138	1412

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WATER BUDGET DATA

Canada		J	F	M	A	M	J	J	A	S	O	N	D	Yr
Sydney,	PE	0	0	0	16	56	92	120	112	76	45	16	0	533
Nova Scotia	P	131	112	113	102	87	72	86	95	88	11	131	138	1166
Ottawa,	PE	0	0	0	26	81	116	138	115	75	34	0	0	585
Ontario	P	75	62	69	69	63	89	86	65	82	74	76	66	876
Sudbury,	PE	0	0	0	17	74	113	130	110	73	33	0	0	550
Ontario	P	44	37	48	60	58	70	71	61	89	84	73	50	745
Toronto,	PE	0	0	0	30	74	112	138	119	81	41	11	0	606
Ontario	P	69	62	66	63	74	68	75	69	74	62	70	67	819
Charlottetown,	PE	0	0	0	15	59	97	127	115	76	43	10	0	542
Prince Edward Is.	P	96	77	80	71	68	66	76	85	86	103	91	101	1000
Montreal,	PE	0	0	0	27	81	119	139	121	77	37	2	0	603
Quebec	P	96	77	88	66	80	87	95	88	93	87	90	91	1038
Quebec,	PE	0	0	0	16	73	112	132	111	72	33	0	0	549
Quebec	P	88	70	77	60	80	93	102	101	91	87	82	82	1013
Regina,	PE	0	0	0	23	77	113	132	110	61	21	0	0	537
Saskatchewan	P	13	9	17	19	47	83	60	45	34	22	15	11	375

M-5-10

Water Budget Instructions

Water budgets can be fun! In addition to providing a quick picture of climate students enjoy doing them once they understand the process. Water budgets are easy to plot once the students get used to the terms and methods.

The following instructions for the water budget for Houston can be used to guide students through plotting the first budget. This plotting will go slowly, but afterwards others should be faster. A completed graph and chart follow.

As you begin, it is helpful to compare the water budget to income, expenses, and a bank account.

abbreviation	Term	Relate To
P	precipitation	income - your pay check
PE	potential evapotranspiration (determined largely by amount of solar energy)	bills due - what you owe
P-PE	precipitation minus potential evapotranspiration	difference between income and and bills (+ or -)
Δ ST	change in storage (capillary water added or withdrawn)	change in bank account for the month, deposit or withdrawal
ST	storage (capillary water) (assume an average storage capacity of 100 mm)	balance in bank account (remember, this is a strange bank--you cannot have over $100 in your account)
AE	actual evapotranspiration (determined by energy and water available)	bills paid - what you were able to pay of what you owed by using income and, if necessary, withdrawing from bank
D	deficit - for this month only; do not add for other months	amount you could not pay of month's bills - do not add to deficit of other months
S	surplus - excess water which does not cling to soil becomes either ground water or run-off	extra income not needed to pay bills or to bring your bank balance up to $100. You cannot accumulate this from month to month if bank account is full ($100) so use it as you wish

The water budget data you are given are the averages for the location. Select a month to begin when you are sure the soil storage capacity is either full or empty. For example, data for Houston show an annual precipitation of 1168 mm and only 1095 mm for potential evapotranspiration. For the year, there is more water than is needed. But, both precipitation and need vary from month to month.

Steps to select beginning month

1. Subtract PE from P (P-PE) for each month. Result may be positive or negative.

2. When the sum of the positive difference for several consecutive months is more than 100, you can be sure storage (capillary water capacity) is full. For Houston, there is a positive difference of 70 for January and 52 for February. That is already more than 100. Write 100 in the line for storage (ST) under February and begin working with March.

(NOTE: In an arid region where PE for year is greater than P, look for a month when you know storage would be exhausted. For Houston, this would be true in July. If you wish, you can enter 0 on the storage line for July and begin to work with August.)

Now that you have decided where to begin:

3. In March P (your income) was 85, PE (bills) was 50. Since P (income) is greater than PE (bills), pay all your bills and write 50 under AE. (Plants had all the moisture available that they could use with the energy available)
4. Your storage is full--the balance in February was 100 and the soil can't hold any more moisture. The bank won't add more to your account. There is no change in storage so write 0 in the ΔST line for March (no deposit, no withdrawal)
5. Balance remains 100. Write 100 on ST line.
6. There was no deficit. You had enough to pay bills. Write 0 on the D line.
7. You had 35 mm more P than you needed to pay bills or fill your bank account. Write 35 on the S line. That is surplus; have a party!
8. Repeat for April. Again P is greater than PE (income greater than bills and bank account is full). Again you have a surplus, but just enough for a movie this time. P-PE=9, ΔST = 0, ST = 100, AE = 83 (all bills paid), D = 0, S = 9.
9. Then comes May with P = 119, PE = 125. Your bills are too big. What do you do? P - PE = -6. Go to the bank and withdraw 6. (ΔST = -6). Now your balance is 100 - 6 = 94, ST = 94. At least you can pay your bills: P 119 + 6 ΔST = 125 AE. Enter 125 on AE line. D = 0 again but no money for a celebration in May. S = 0.
10. June P 116, PE 166, P-PE = -50. Sad! Again to the bank to withdraw 50 (ΔST = -50). Capillary water is getting low. ST now is 94 (from May) - 50 June withdrawal = 44. ST 44 for June. But you did manage to pay your bills: 116P + 50ΔST (from bank) = 166. Enter 166 on AE line (bills paid). No deficit; D = 0, No surplus; S = 0.
11. July things get worse. Income is less, bills are higher. P = 98, PE = 182, P=PE = -84. Again you go to the bank, but you have only 44 left from June. Take the 44 out: ΔST = -44. Now ST = 0. Add P (income) 98 + ΔST (withdrawn) 44 = 142. That's all the money you have so you pay bills AE = 142. You owed 182 so you have a deficit for July of 40. D = 40. S = 0.
12. Continue with August. P-PE = -73. There is no capillary water left for plants--no money in your bank account so you can't withdraw. ΔST = 0. ST = 0. All you can spend is what you received in income (P) so AE is equal to P or AE = 99. PE (bills) = 172. Your deficit, D = 73. S = 0.
13. September is bad but not as bad as August. P-PE = -32, ΔST - 0, ST = 0, AE = 103, D = 32, S = 0.
14. October! Income falls but so do bills. P 95 - PE 81 = + 14, but no parties. That extra 14 goes right to the bank account (capillary water). ΔST = +14 (deposit), ST = 0 (balance from Sept.) + 14 =14

for October. Pay all bills, AE = 81. D = 0. S = 0.

15. November. Life is improving. P 89 - PE 39 = +50, right to the bank. ΔST = +50. ST = 14 (from October) + 50 = 64. Pay all bills. AE = 39. D = 0. S = 0.
16. December is Great! P-PE = 108-20 = +88. First to bank which will hold only 100. Balance in ST from November = 64. You must deposit 36 to make 100. ΔST = +36. ST = 64 + 36 = 100. Capillary capacity is full and you still have 88 - 36 = 52 more than needed, for AE = 20(PE). D = 0. S = 52, just in time for Christmas.
17. January is next. (Remember, these are averages so you go back to the first of the year.) P (89) - PE (19) = +70. Storage is full already; therefore, ΔST = 0. ST = 100. AE (bills) = 19 (all paid). D = 0. S = 70.
18. February: P - PE = 52. ΔST = 0. ST = 100. AE = 23. D = 0. S = 52.
19. Your data table is complete except for filling in annual data. This is needed only for P-PE, AE, D, and S.

Graph Instructions

1. On the graph paper, plot points for P in the center of the space above the letter of the month. (See sample graph) Connect points in color or with dashed line.
2. Plot points for PE. Connect these points with a different color or with a solid line.
3. Plot AE data.
4. The spaces between the lines (P and PE) represent either deficit, surplus, deposit in storage, or withdrawal from storage. Decide what the space represents for each month. Use the symbols given on the graph.

Key to illustrate the areas of the graph which represent:

Surplus - PE and AE less than P after storage is filled.

Deficit - AE and P less than PE and storage depleted.

Deposit - PE and AE less than P before storage is filled.

Withdraw - PE and AE greater than P before storage is depleted.

Examples:

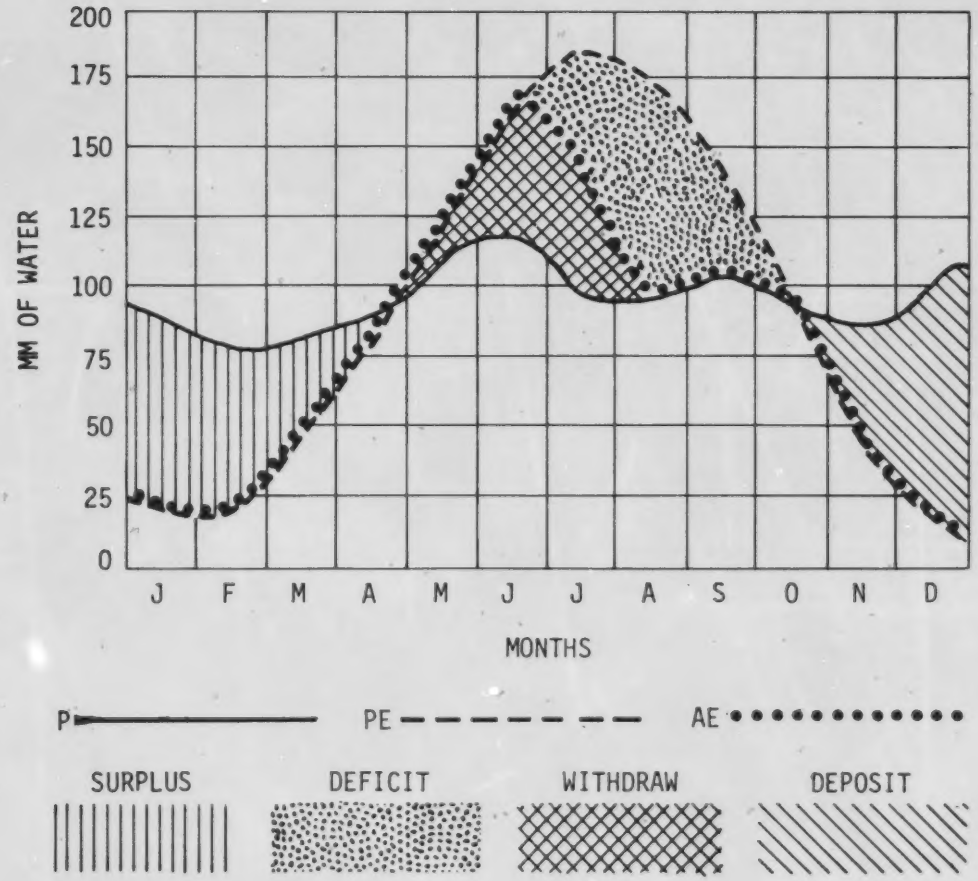
January - all 70 units are surplus
May - all 6 units are withdrawal
July - 44 are withdrawal, 40 are deficit
October - all 14 are deposit
December - 36 are deposit, 52 are surplus

Have students answer questions similar to the following based on their water budgets.

1. Compare the P and PE curves. When are they high? When are they low? Do they match? Why or why not?
2. Why is PE so high in July and so low in January?
3. When do you begin to have a surplus? Why?
4. When do you begin to have a deficit? Why?
5. During which months would plants depend on stored water?
6. When would irrigation be needed?
7. Why are annual figures deceptive if you are interested in growing crops in an area?

WATER BUDGET FOR HOUSTON

	J	F	M	A	M	J	J	A	S	O	N	D	YEAR
P	89	75	85	92	119	116	98	99	103	95	89	108	1168
PE	19	23	50	83	125	166	182	172	135	81	39	20	1095
P-PE	+70	+52	+35	+9	-6	-50	-84	-73	-32	+14	+50	+88	73
ΔST	0	0	0	0	-6	-50	-44	0	0	+14	+50	+36	—
ST	100	100	100	100	94	44	0	0	0	14	64	100	—
AE	19	23	50	83	125	166	142	99	103	81	39	20	950
D	0	0	0	0	0	0	40	73	32	0	0	0	145
S	70	52	35	9	0	0	0	0	0	0	0	52	218



TITLE: Construction of Weather Maps

John Kline
Madison High School
Vienna, Virginia 22180

PURPOSE:

1. To place symbols on a weather map to represent one day's weather pattern;
2. To make pressure, temperature, wind and precipitation maps based on given data;
3. To locate and draw in fronts on a map;
4. To put all of the maps together to make one complete weather map; and
5. To make predictions of weather conditions based on the completed map.

MATERIALS:

1. data chart
2. blank weather map
3. four sheets of white paper (ditto paper) or tracing paper
4. instruction sheets

PRE-LAB PREPARATION: (Three fifty-five minute class periods)

1. Duplicate blank weather maps, instruction sheets and data charts.
2. This lab should be done after students have been introduced to drawing isolines (contour lines isobars or isotherms). After an introduction to atmospheric temperatures, pressures, and air masses, it could be used as a summary of a weather unit.
3. An example of student results is given for each of the maps plus a completed weather map.

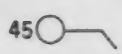
PROCEDURE:

1. Transfer all weather data onto the map of the United States. Use the symbols and methods of the weather bureau as follows:

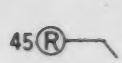
location of the city (example: Richmond, Virginia)

wind direction (E)

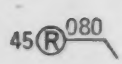
wind speed (14 mph) look at bottom of map for symbols



temperature 45°F (plot temperature on the upper left side of the circle)



cloud cover (rain) Ⓡ = rain Ⓕ = fog ● = cloudy ○ = clear



Barometric pressure (1008.0). Write only the last three digits. Leave out the decimal.

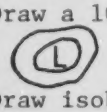
Make sure all data are plotted neatly and dark enough, so that you can trace the data onto white paper when held up to the window. Use a pencil, not a pen, for tracing.

2. MAKE A TEMPERATURE MAP

a) Cover your map with a white sheet of paper and trace the outline of the United States.
b) Write on this "map" the temperature data for each station. (you should not draw circles just write the number that represents temperature)
c) Draw an isotherm (temperature line). You should draw isotherms for 30^{o}, 40^{o}, 50^{o}, 60^{o}, 70^{o}, 80^{o}. Draw lines lightly so that they can be changed if it becomes necessary. Label each line. (hint: start with the line for 60^{o})
d) Notice that at some places the lines are close together. What does this indicate about temperatures in those areas?

3. MAKE A PRESSURE MAP

a) Follow the same procedure as the temperature map, except, copy the numbers representing the pressure data only.
b) Locate the lowest pressure and make an "L" to show this location on your map. Locate the highest pressure and mark this location with an "H".
c) Draw a 1004.0 (040) isobar around the L.



d) Draw isobars for 1008.0 (080), 1012.0 (120), 1016.0 (160), 1020.0 (200), 1024.0 (240), and 1028.0 (280).
e) In certain areas of your map the isobars should make abrupt changes in direction. Why is this?
f) Label each line.

4. MAKE A PRECIPITATION MAP

a) Follow the same procedure as for the temperature and pressure maps except indicate the sky conditions on your map with the proper symbol.
b) Outline and shade in the areas which had precipitation reported.
c) Precipitation usually occurs along warm and cold fronts.

5. MAKE A WIND MAP

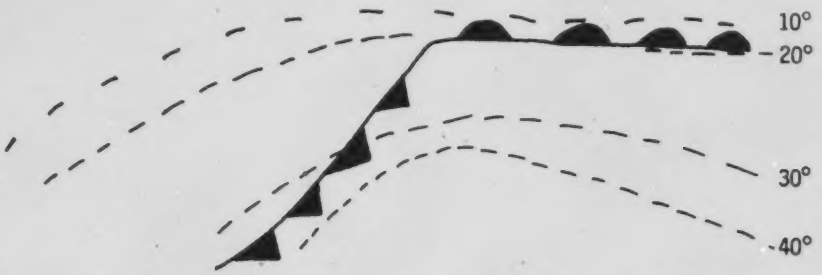
a) Write the wind direction and speed data on another map.
b) Wind direction changes abruptly along fronts. Can you locate the fronts?

LOCATING FRONTS ON THE WEATHER MAP

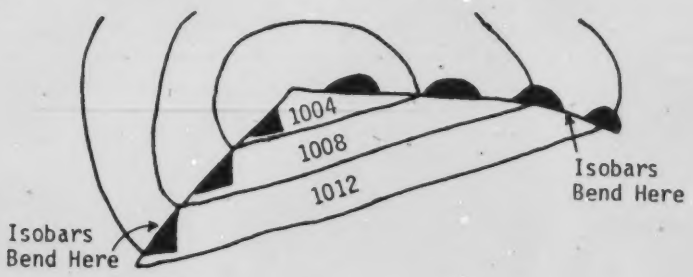
Fronts occur along the boundaries between cold polar air masses and warmer tropical air masses. These are the locations where precipitation and weather changes occur.

LOCATE THE FRONTS WHERE YOU OBSERVE:

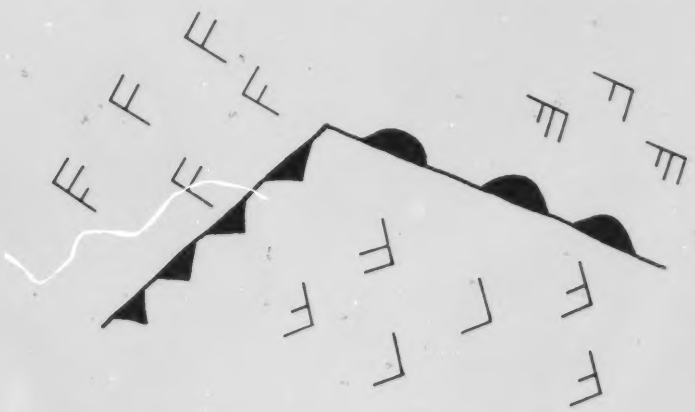
1. Abrupt changes in temperature - on your map for temperature; (Look for places where the isotherms come close together and thus indicating a large temperature change between stations that are close together.)



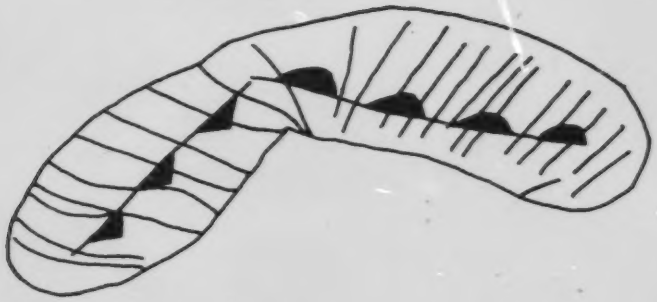
2. Abrupt changes in the direction of isobars on the pressure map;



3. Abrupt changes in wind direction and wind speed;



4. Precipitation and cloudy skies.



5. LOW PRESSURE AREAS - usually fronts extend out of low pressure areas. Cold fronts ▲▲▲ represent areas where cold air is displacing warm air and warm fronts ◗◗◗ represent areas where warm air is displacing cold air.

   Look at each of your maps and try to decide for each, where the cold and warm fronts are located.

   COMPLETED WEATHER MAP

   To make a completed weather map draw the isotherms, isobars, fronts and precipitation areas of all the maps onto your original map you were given.

   Questions (based upon the completed map)

   1. If weather systems move about 600 miles per day in a north-easterly direction, what would be your weather prediction for New York City, on the following day?

   2. What would be your prediction for Washington D.C. and Chicago?

   3. What would be your prediction for your own area?

130°
120°
110°
100°
90°
80°
70°
45°
40°
35°
30°
25°
Seattle
Winnipeg
Sault Ste. Marie
Boston
Bismarck
Butte
Minneapolis
Detroit
Chicago
Cincinnati
Richmond
San Francisco
Lake
City
Chattanooga
Charleston
Oklahoma
Rock
Atlanta
Jacksonville
Los Angeles
Phoenix
Denver
Fort Worth
New Orleans
Tampa
Galveston
Miami
COLD FRONT
WARM FRONT
STATIONARY FRONT
OCCLUDED FRONT
CLEAR
PARTLY CLOUDY
CLOUDY
MISSING
DIRECTION OF WIND
WEST WIND
EAST WIND
RAIN
SNOW
FOG
HURRICANE
WIND SCALE miles per hour
Calm
1-2
3-8
9-14
15-20
21-25
26-31
32-37
38-43
44-48
49-54
55-60
61-66
67-71
72-77

M-6-5

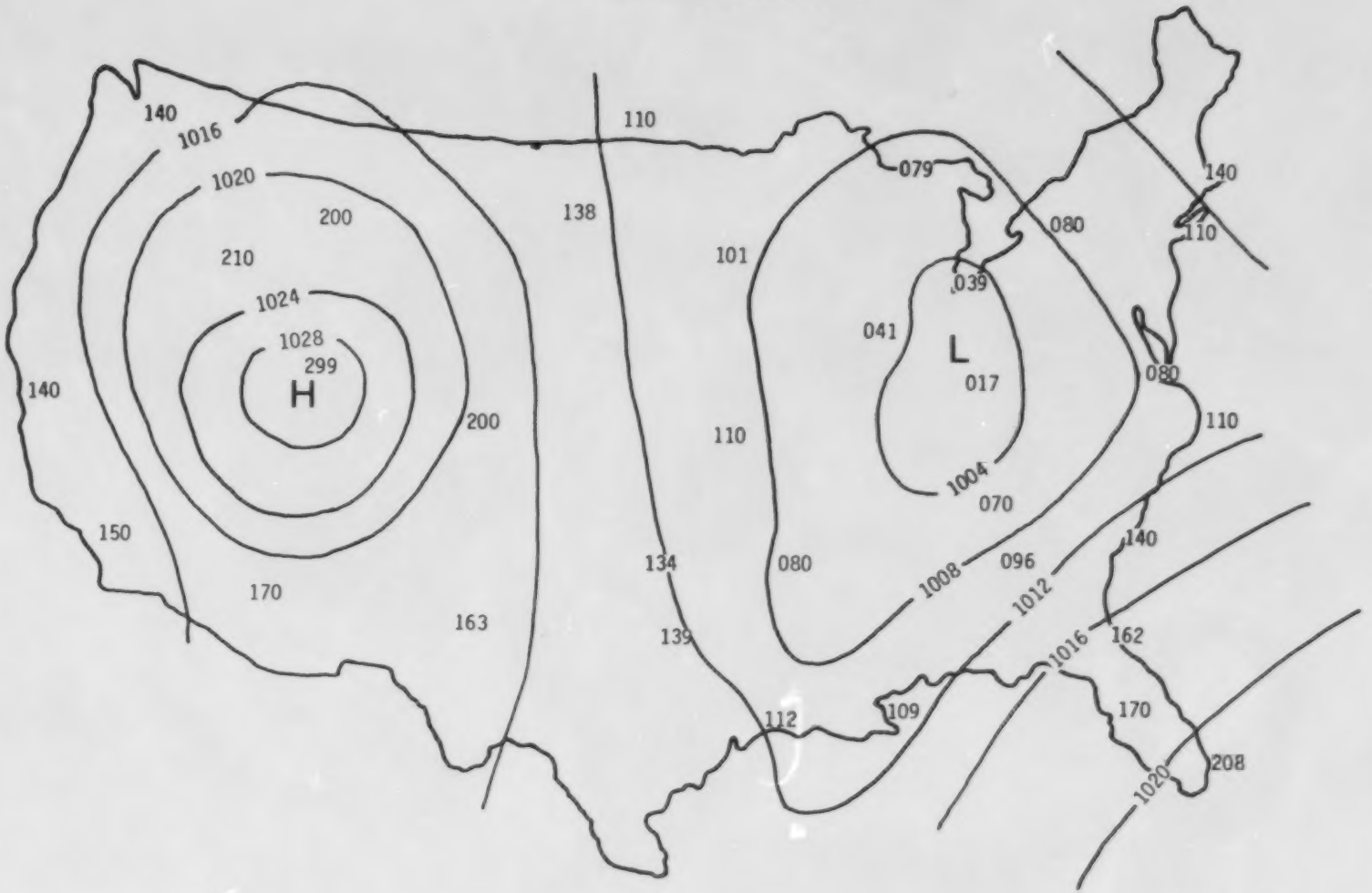
WEATHER DATA

Station	Wind Direction & Velocity (MPH)		Temp.	State of Sky or Precipitation	Barometric Pressure (millibars)
Boston, Mass.	N.E.	7	39	Cloudy	1014.0
New York, N.Y.	E.	9	42	Rain	1011.0
Buffalo, N.Y.	N.E.	10	40	Cloudy	1008.1
Richmond, Va.	E.	14	45	Rain	1008.0
Detroit, Mich.	N.E.	16	44	Rain	1003.9
Sault Ste., Marie, Canada	N.E.	12	33	Pt. Cloudy	1007.9
Chicago, Ill.	N.W.	10	40	Fog	1004.1
Cincinnati, Ohio	S.W.	19	60	Rain	1001.7
Chattanooga, Tenn.	S.W.	11	70	Pt. Cloudy	1007.0
Atlanta, Ga.	S.	18	71	Pt. Cloudy	1009.6
Hatteras, N.C.	S.E.	23	68	Cloudy	1011.0
Charleston, S.C.	S.E.	22	71	Pt. Cloudy	1014.0
Jacksonville, Fla.	S.	7	72	Clear	1016.2
Tampa, Fla.	S.E.	13	77	Pt. Cloudy	1017.0
Miami, Fla.	Calm		80	Clear	1020.8
New Orleans, La.	S.W.	24	76	Rain	1010.9
Galveston, Texas	N.W.	18	60	Rain	1011.2
Little Rock, Ark.	N.W.	26	46	Rain	1008.0
Minneapolis, Minn.	N.W.	28	34	Pt.Cloudy	1010.1
Winnipeg, Canada	N.W.	30	27	Cloudy	1011.0
Bismarck, N.D.	W.	24	30	Pt. Cloudy	1013.8
Kansas City, Mo.	N.W.	7	50	Clear	1011.0
Oklahoma City, Okla.	N.W.	17	54	Clear	1013.4
Fort Worth, Texas	N.W.	31	58	Clear	1013.9
Roswell, N. Mex.	N.	18	57	Clear	1016.3
Phoenix, Ariz.	N.E.	6	68	Clear	1017.0
Denver, Colo.	N.W.	5	51	Clear	1020.0
Butte. Mont.	S.	23	47	Pt. Cloudy	1020.0
Seattle, Wash.	S.E.	12	55	Pt. Cloudy	1014.0
Boise, Idaho	S.E.	30	49	Clear	1021.0
Salt Lake City, Utah	W.	2	57	Clear	1029.9
Los Angeles, Calif.	N.E.	14	62	Clear	1015.0
San Francisco, Calif.	E.	7	60	Clear	1014.0

PRESSURE: PARTIALLY COMPLETED

M-6-7

PRESSURE COMPLETED



M-6-8

M-6-9

TEMPERATURE

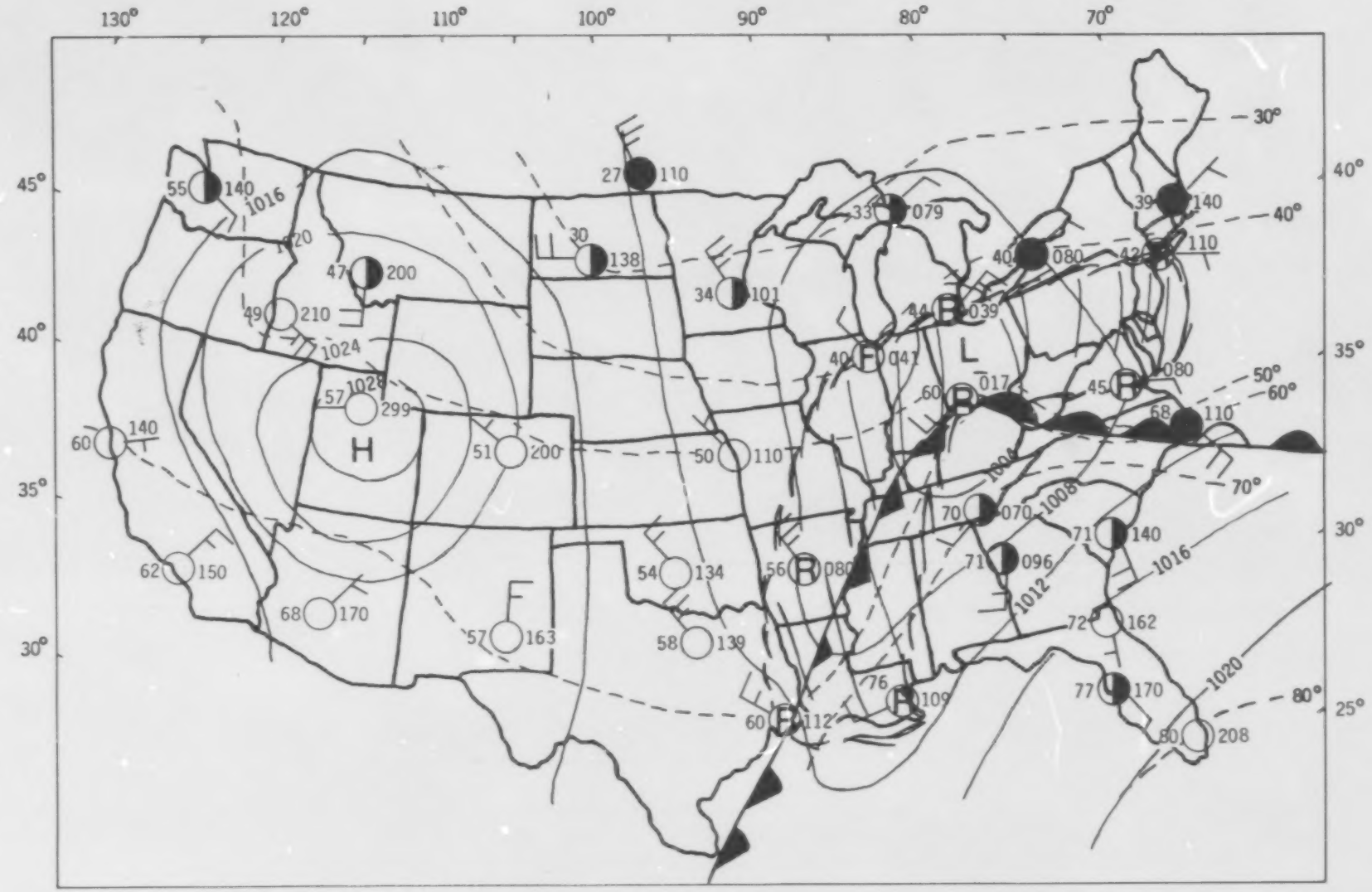
WIND DIRECTION AND SPEED

M-6-10

PRECIPITATION

M-6-11

COMPOSITE WEATHER MAP



M-6-12

TITLE: Meteorology Maze

Sharon Charles
and Richard Scheele
Stonewall Jackson Junior High School
Mechanicsville, VA 23111

PURPOSE: To provide vocabulary reinforcement in an entertaining way.

MATERIALS: 1. puzzle
2. pencil

PRE-LAB PREPARATION: Prepare stencil. Activity takes approximately 30 minutes.

PROCEDURE: Locate the circle the words relating to meteorology. The words run diagonally, horizontally, and vertically.

N Y S U R R I C B R O W W N M R O T S
H U Z Z E V A P O R A T I O N S T S I
P T S U T A R T S O R F I L L L E U T
A L I F E L O B M Y S P A M O E Y L J
R O H U M I D I T Y T O M T D E E D N
G O F A O W E A T H E R S T A T I O N
O V P U R R I P H N O D R A Z Z I L B
R A I N G A U G E U X P Z Z G T H D S
A N G R Y E E Z E E R B P B A O U E A
B E U V H W F O D A N R O T F O T N T
M M B Y C R V A N E W R I E L U H O U
E O D I O R E N A E N P A C I R U T R
R M W N D J I C D W I P C A A L N S A
C E T A H A M C A C M Z R L O N D L T
U T H E R M O M E T E R O R E W E I E
R E B L U M T R T A R P I T S A R A D
Y R E R E H P S O M T A S N O W R H X

CIRRUS
EVAPORATION
FROST
STRATUS
MAP SYMBOL
HUMIDITY
WEATHER STATION
SLEET
BLIZZARD
PRECIPITATION
STORM
RAIN GAUGE
BAROGRAPH
ANEROID
HAILSTONE
CLEAR
HURRICANE
CLOUD
POLAR
ATMOSPHERE
ANEMOMETER
MAP
THERMOMETER
DEW
FRONT
TORNADO
HYGROMETER
SNOW
WARM
DROP
SUN
MERCURY
BREEZE
AIR
SATURATED
ICE
FOG
VANE
LOW
THUNDER
SEED
EYE

TITLE: Earth Science Bingo Instructions

Sharon Charles
Stonewall Jackson Junior High
Mechanicsville, Virginia 23111

OBJECTIVE: To provide an entertaining review of earth science terms.

MATERIALS:

1. 50 earth science terms
2. "Bingo Boards"
3. small, colored paper squares
4. pencil
5. words and definitions for teacher

PRE-LAB PREPARATION: Teacher must run off one board for each student. Colored paper cut on a paper cutter can be used for chips. (Suitable substitutes may be used). A list of 50 words should be written on the blackboard or written on paper and handed out to each student. This exercise can be completed in one 55 minute class period.

PROCEDURE:

1. Give each student 1 blank "board" and a handful of "chips". List the 50 terms on the board or list them on a handout sheet. The student should randomly fill this board with only 24 of the 50 terms, leaving the middle space free. No two boards should be alike. (Collect handouts for future use.)
2. The teacher should pick a definition from a "hat" and the student should cover the correct corresponding answer on his board.
3. Prizes for each game are encouraged. There should be approximately five winners per class period. A candy bar is great incentive to win!
4. Variations can be played, for example, 4 corners, T, cover the board, or regular Bingo.
5. Hints: At Christmas, a small candy cane may be drawn on the back of the board. Towards the end of class, this candy cane may be used to identify the winner of a door prize. (Teacher should decide the item to be given as a door prize).

B	I	N	G	O
		FREE		

METEOROLOGY BINGO ITEMS

Ann Dorr
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1. radiative balance - when the energy absorbed by a body equals the amount that it radiates

2. insolation - incoming solar radiation

3. ozone layer - O_3 layer in the upper atmosphere which absorbs ultraviolet radiation

4. troposphere - layer of atmosphere next to earth's surface, heated from below and where weather events take place

5. stratosphere - second layer of atmosphere above earth's surface, warmed from the top by direct solar radiation

6. isobar - line connecting points of equal pressure

7. isotherm - line connecting points of equal temperature

8. cumulus - billowy clouds formed by vertical air movement

9. cirrus - high thin ice crystal clouds

10. stratus - layer of sheet-like clouds extending over much of sky

11. nimbus - rain clouds

12. cyclone - large nearly horizontal eddy or low pressure center into which winds spiral counter-clockwise in the northern hemisphere and clockwise in the southern

13. trade winds - tropical winds which blow generally from east to west

14. westerlies - belt of mid-latitude winds in which general air movement is from west to east

15. polar easterlies - winds from north and south poles deflected so they blow from east to west

16. doldrums - belt of generally rising air producing low pressure, calms, clouds, and rain near the equator

17. horse latitudes - high pressure belt of generally clear calm weather centered generally along 30^{o} N. and S. latitude

18. Hadley Cell - convective circulation between the equator and about 30^{o} N. and S. due to unequal heating and earth's rotation

19. Coriolis Effect - deflection of winds and currents due to earth's rotation

20. Polar Front - low pressure, turbulent zone where cold polar easterlies meet warmer westerlies

21. monsoon - seasonal winds blowing from sea to land in summer and land to sea in winter

22. melt - change of state from solid to liquid

23. evaporate - change of state from liquid to gas

24. condense - change of state from gas to liquid

25. sublimate - change of state from gas to solid or solid to gas without passing through liquid phase

26. latent heat - stored or hidden heat absorbed without change of temperature during change of state

27. relative humidity - water vapor in air as a percentage of what air could hold at same temperature

28. condensation nuclei - tiny particules of dust, salt, pollen, etc. in air on which water condenses to form cloud droplets

29. adiabatic temperature change - temperature change resulting from expansion or compression of a parcel of air

30. fog - ground level clouds

31. drizzle - tiny drops of precipitation

32. sleet - clear pellets of ice formed when rain drops fall through a layer of cold air and freeze

33. hail - large pellets or spheres of ice formed in cumulonimbus clouds with strong updrafts

34. snow - hexagonal shaped ice crystals formed as water vapor sublimates and accumulates on ice nuclei

35. cold front - leading edge of a cold air mass which is invading a warm air zone

36. warm front - leading edge of a warm air mass moving into a region occupied by cold air

37. air mass - large mass of air with nearly uniform temperature and moisture content at a given altitude

38. stationary front - boundary between cold and warm air masses when neither is advancing into the region of the other

39. occluded front - one front, usually a cold front, overtakes another, usually a warm front, lifting the intervening air mass upward off the ground

40. jet stream - narrow zones of upper air winds which attain velocities up to 450 km per hour

41. hurricane - a large intense low pressure center which developes over warm tropical oceans and produces violent storms-tropical cyclone

42. tornado - smallest but most violent of all known storms - air spirals with tremendous speed and appears as a dark funnel cloud

43. dew point - temperature at which air becomes saturated and moisture begins to condense on surfaces

44. anemometer - an instrument which measures wind speed.

45. thermometer - an instrument which measures temperature

46. barometer - an instrument used to measure atmospheric pressure

47. convective circulation - vertical movement of air or liquid due to density differences usually induced by differential heating

48. saturation vapor pressure - vapor pressure in air is just balanced by pressure within liquid so that exchange of molecules stops

49. dew - water droplets condensed on surfaces

50. frost - ice sublimated onto surfaces below the freezing point from water vapor in the air

51. weather - the atmospheric conditions which exist at a place at a given time

52. climate - average weather conditions over a long period of time

53. greenhouse effect - describes the way long wave radiation from the earth is trapped by water vapor and CO_2 in the atmosphere

54. radiation - energy transfer through space

55. conduction - transfer of energy from one thing to another by direct contact - most efficient energy transfer in solids

56. convection - main method of energy transfer in liquids and gasses

57. temperature - average kinetic energy of molecules

58. temperature inversion - a condition which exists when the temperature increases with altitude

OCEANOGRAPHY

TITLE: Oceanography: Subsurface Circulation

Adapted from:
Exploring Inner Space:
A Guide to Teaching Marine Science
Mathematics and Science Center
Glen Allen, Virginia 23060

PURPOSE: To have the student investigate the concept of thermohaline circulation, which results from temperature (thermo) and salinity (haline) differences.

MATERIALS:

1. 2 beakers
2. 1 medicine dropper
3. salt
4. food coloring or dye
5. access to cold and hot water

PRE-LAB: If the teacher wants to use the question below, some research on the Mediterranean Sea currents and the effects of density and salinity on transmission of sound waves would be most helpful.

PROCEDURES: (Time; one 55 minute class period)

Pour 200 ml of fresh water into a beaker. In another container color some salt water with the food coloring. Add a few drops of the dyed salt water to the beaker of fresh water at the surface of the water. Observe and record the results. Next pour 200 ml of salt water instead of fresh water, into the beaker. In another container color some fresh water with food coloring. By placing the medicine dropper deep into the beaker of salt water, introduce a few drops of the dyed fresh water at the bottom of the beaker. Observe and record the results. Design some of your own experiments to investigate the effects of temperature differences.

1. During World War II, German and Italian submarine personnel used the currents of the Mediterranean Sea to their advantage. They would shut off the submarine engines and drift in and out of the Strait of Gibraltar past the British blockades. Why and how were they able to accomplish this?

CONCLUSION: On the basis of the experiment, describe some effects which result from a difference in temperature and/or salinity of water samples.

TITLE: Oceanography: Density of Fresh and Salt Water

Adapted from:
Exploring Inner Space:
A Guide to Teaching Marine Science
Mathematics and Science Center
Glen Allen, Virginia 23060

PURPOSE: To investigate the density of fresh and salt water by the balance method.

MATERIALS:

1. 1 double pan balance
2. 1 100 ml graduated cylinder
3. tap water
4. paper towels
5. 1 teaspoon
6. 1 box of table salt
7. 1 150 ml beaker

PROCEDURE: (Time, one 55 minute class period)

Dry the graduated cylinder well with a paper towel. Mass the graduated cylinder as accurately as possible. Add 90 ml of tap water to the graduated cylinder and weigh again. Determine the mass of the water by subtracting the mass of the cylinder from the mass of the cylinder and water combined. Determine the density of the tap water by using the following formula:

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

$$= \frac{\text{grams of water}}{\text{milliliters of water}}$$

Dissolve approximately ½ teaspoon of salt in 100 ml of water in the 150 ml beaker. Add 90 ml of this solution to the graduated cylinder. Determine the density of this solution. Repeat this experiment several times keeping the amount of water the same but increasing the amount of salt by ½ teaspoon each time. Construct a table from your results.

CONCLUSION: How does salt affect the density of water?

TITLE: Oceanography: Construction and Use of Secchi Discs

Adapted from:
Exploring Inner Space: A Guide To Teaching Marine Science
Mathematics and Science Center

PURPOSE: To construct several secchi discs and have the students to use them to measure the turbidity of some local streams, lakes, ponds, or rivers.

MATERIALS: (per disc)

1. 1 metal or wood disc about 30 cm diameter
2. 3 eye screws
3. 1 10 cm diameter ring (heavy plastic or metal)
4. 3 pieces of one meter length of heavy cord
5. black and white paint (waterproof)
6. heavy weight (brick with holes)
7. large bolt (about 1 cm diameter and 12 cm in length), nut and two flat washers.
8. Long heavy line for sounding cord (approximately 5 meters long)

PROCEDURE:

a. Paint the entire disc white.
b. Divide the surface of the disc into four equal areas.
c. Paint two of the four equal areas opposite each other black.
d. Drill a 1 cm diameter hole in the center of the disc.
e. Divide and mark the circumference of the disc into three equal lengths.
f. If a metal disc is used, drill a hole 2 cm from the edge of the disc at each of the three circumference divisions.
g. If a wood disc is used, do not drill the holes. Screw in the eye screws at the marked distances along the outside of the disc.
h. Run a cord, one meter long, from each hole or eye screw to the ring. Tie the cords to the ring so that the disc hangs parallel to the ground.
i. Tie the sounding cord to the ring. Weight the wood disc by attaching the brick to the underneath side of the disc. The brick can be attached by inserting the 12 cm bolt through the hole in the center of the disc and through the center hole of the brick so that the weight of the brick is evenly distributed. Be sure to use washers large enough to prevent bolts from sliding through the hole in the brick.

Using the Secchi Disc:

At each station:

a. Lower the disc into the water until it can barely be seen and record the depth;
b. Continue to lower the disc until it disappears and record the depth;
c. **Raise the disc until it can barely be seen and record the depth;**
d. Average the first and third depth readings for each spot. This will be the figure that describes the clarity of the water at each spot.

CONCLUSION: When students use the secchi disc, they should discover that water varies in its clarity and should be able to relate this variance to how materials in the water affects its clarity.

TITLE: Oceanography: The Sargasso Sea

Sharon Charles &
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Stonewall Jackson Junior High School
Mechanicsville, VA 23111

PURPOSE: To acquaint students with the Sargasso Sea and its legend. To plot on a map the location of the Sargasso Sea. To locate and label on a map the Gulf Stream, North Atlantic Current, Canaries Current, and North Equatorial Drift.

MATERIALS:

1. worksheets
2. colored pencils

PRE-LAB: Prepare stencils

Prepare background material on the Sargasso Sea. Although ocean liner captains of today would probably smile at this, "the legend is that the seaweed was very dangerous and would trap ships". In 1492, Columbus noticed the unusual plant. His sailors became alarmed when the boat seemed to slow down for a few days and Columbus made note of this in his log. Portuguese sailors named the seaweed "salgazo" because its air bladders reminded them of the small grapes which grow near their homes. The stories increased and captains were warned to stay away from this area. William Beebe sailed there in 1925 and discovered there were no sea monsters as had been reported and the patches of seaweed were no bigger than a man's head. However, it was found to be more extensive than stated in reports. It covers an area of 3,956,000 kilometers^2 from the Mid-Atlantic to near the Atlantic coast and because of changing weather conditions, its location changes.

PROCEDURE: (Time; 1 class period)

Students should color land all one color. On the map label the latitude and longitude lines. Using the given latitude and longitude points, plot the outer boundary and the inner boundary of the Sea. Color each boundary a different color. Using lines and arrows (⟶), label and show direction of the currents that surround the Sargasso: Gulf Stream, North Atlantic Current, Canaries Current, and North Equatorial Drift. Color the ocean and color each color code box.

THE SARGASSO SEA

Directions: Using the following latitude and longitude lines, plot the outer boundary and the inner boundary of the Sargasso Sea.

Outer Boundary

Latitude	Longitude
40	70
37	73
30	77
28	77
25	75
21	70
19	65
17	60
18	52
19	50
20	45
20	40
22	35
26	31
30	30
35	26
40	30
40	35
38	41
35	50
34	58
35	60
38	62
43	62
43	67

Inner Boundary

Latitude	Longitude
33	70
30	72
28	70
25	65
23	60
24	54
26	50
28	45
30	40
34	40
35	43
35	50
34	58
33	61
33	66

MAP SHOWS THE AREA OF THE SARGASSO SEA*

Inner Boundary of Sargasso Sea

Outer Boundary of Sargasso Sea

Water

Land

*Map not intended to be precise in detail

TITLE: Oceanography: The Ocean Bottom

Janice O. Wax
Orange County Schools
Orange, Virginia 22960

PURPOSE: To chart the bottom of a model ocean floor; to identify and label the geologic structure of a model ocean floor; to familiarize students with a method of determining ocean depth and ocean floor structure.

MATERIALS:

1. large cans (the size of large vegetable cans used by schools is good),
2. "Sacrete" cement mix,
3. a small piece of square fencing wire,
4. a ruler,
5. a piece of glass tubing the length of the ruler (ends should be fire-polished to avoid cutting),
6. plastic fishing line,
7. a lead sinker,
8. graph paper,
9. pencil,
10. water,
11. blue dye (soluble),
12. milk (very small amount),
13. graph paper,
14. masking tape,
15. pencil,
16. colored pencils.

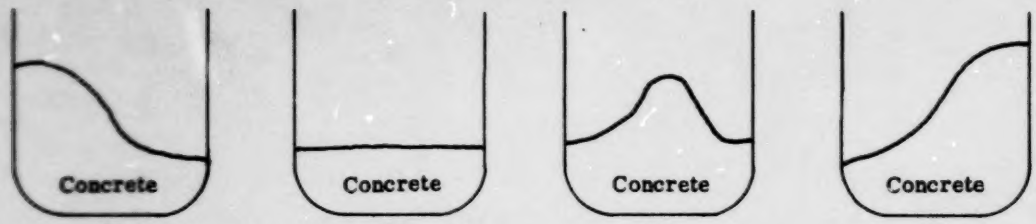
PRE-LAB: This investigation is designed to give students the opportunity to determine depth by using a weighted line, a method used by the first oceanographers. A class discussion of sounding techniques prior to doing the activity would be appropriate.

The teacher must first simulate the ocean bottom by using cement in a series of cans. The teacher should familiarize himself/herself with the following ocean basin features so that they can be formed in the can bottom;

1) continental shelf,
2) continental slope,
3) abyssal plain,
4) mid-ocean ridge,
5) trench,
6) seamount,
7) guyot,
8) island.

optional

Using the number of cans desired (four will be demonstrated here for simplification) pour into the can wet "Sacrete" and shape the desired feature in the bottom. (Take care not to mix the "Sacrete" with too much water, as it will be difficult to mold). The resulting profile of four cans might look like the following:



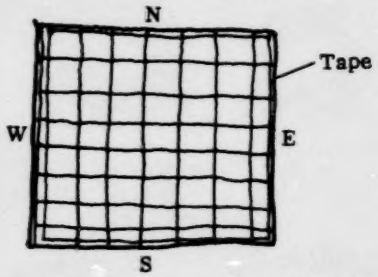
#1 #2 #3 #4

These four show a very simplified view of the ocean basin with continental shelves and slopes in each of the end cans (1 & 4) an abyssal plain (2), and a mid-ocean rise (3). More cans with more detailed features can of course be made. Allow the cement to harden completely.

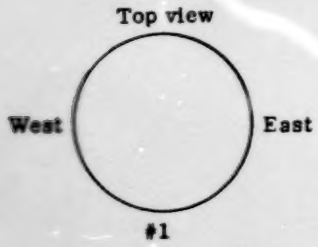
Now fill each can to the same level with water. Add blue dye to simulate ocean water; and a few drops of milk to make the water opaque (so students can not see depth changes through the water).

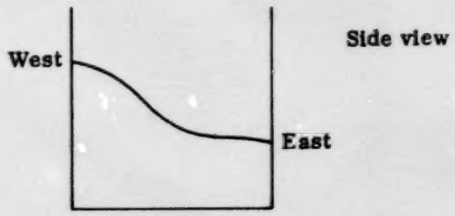
Obtain a small piece of wire mesh from a hardware store. It should measure 30 cm square. Holes must be large enough for the sinker to fit through.

Put tape on the edges, to prevent the wire from cutting the students' hands.

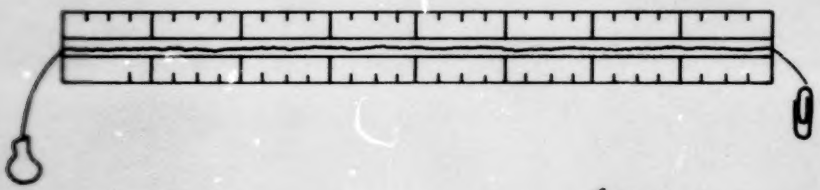


Label the tape N (north), S (south), E (east), W (west) to correspond to geographic directions. Also label the cans (write on adhesive tape) West and East. Remember the profile goes from west to east. Example:



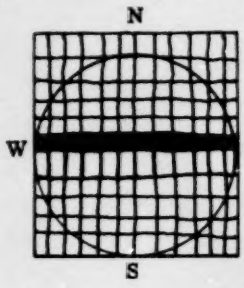


Now tape a piece of glass tubing to a ruler. Pull a 60 cm piece of fishing line through the tube. Attach a sinker to one end (for weight) and a paper clip to the other (so the line will not pull all the way through).



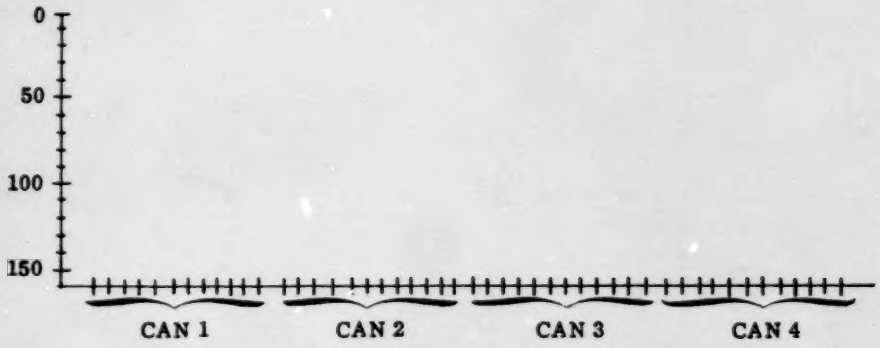
PROCEDURE:

1) Help the students set up their graph paper. To do this, count the number of squares that go over the West/East opening of the can. In the example below, there are twelve (12).



Top view

Now set up the graph as follows:



2) Students should lower the sinker into the can through each hole across the center moving from west to east, and measure how many millimeters the line goes down before it hits bottom for each hole. Plot this information on the graph.

3) When complete, the student should have a profile of their "ocean bottom". Ask them to lable the features of the ocean floor.

CONCLUSION: Discuss the results obtained by the various students and project the limitations of this method of determining the sea floor profile and the depth of the water.

TITLE: Oceanography: The Echo Sounder and the Ocean Floor

Marlene Brewer
Mathematics & Science Center
Glen Allen, VA 23227
and Sharon Charles
Stonewall Jackson Junior High School
Mechanicsville, VA 23111

PURPOSE: Within the great ocean basins, we find many relief features similar to those we encounter on continental land masses. Upon completion of this investigation, one should be more familiar with some of the geological features of the ocean floor, be able to chart a bottom profile, and be able to calculate time intervals using signal data from echo sounders.

MATERIALS:

1. graph paper
2. pencils
3. ruler
4. hand-held calculator

PROCEDURE: (Time; 2 class periods)

Label the horizontal axis of the graph "distance in kilometers". Label the vertical axis of the graph "depth in meters". The horizontal axis should be marked 0 in the lower left corner and extended to 3300 km toward the lower right. The vertical axis should be marked -1800 meters in the lower left corner and extended upward to +200 meters. Keep in mind that sea level is zero (0). All points above sea level are positive (+) and all points below sea level are negative (-). Plot data points on the graph. Have each student to make one calculation of the time-distance sound travel relationships.

CAUTION: In interpreting bottom profiles, keep in mind that although any given profile may show considerable relief, there is usually <u>great vertical exaggeration</u> due to limiting size of illustrations.

Identify;
- continental shelf,
- continental slope,
- trench,
- seamount,
- island,
- guyot,
- basin.

As a ship sailed across the ocean, the data below was received by an echo sounder. Plot this data on your graph paper. Connect all points to draw the ocean bottom profile.

Set of Data	Depth in Meters	Distance in Kilometers
1	60	0
2	60	40
3	0	120
4	-60	161
5	-91	306
6	-366	442
7	-975	644
8	-1219	844
9	-1341	933
10	-1341	1207
11	-1341	1408
12	-1341	1528
13	-1128	1576
14	-914	1609
15	-914	1689
16	-914	1810
17	-914	1890
18	-1127	1971
19	-1432	2011
20	-1432	2292
21	-1280	2333
22	-1005	2381
23	-670	2453
24	-944	2494
25	-1341	2575
26	-1554	2655
27	-1737	2695
28	-1646	2735
29	-1463	2775
30	-1402	2936
31	-1219	2976
32	-914	2992
33	-671	3025
34	-244	3041
35	0	3057
36	+183	3097
37	-122	3137
38	-457	3218

Echo sounding is used to measure the depth to the ocean floor from the surface of the ocean. A signal such as a bell or beeper is sounded from one end of the ship and the echo or returning sound is detected and recorded at the other end of the ship.

The velocity or speed of sound in water is approximately 1524 meters per second.

Depth is calculated by using the formula:

$$D = \tfrac{1}{2}t \times V$$

$$\text{Depth} = \tfrac{1}{2} \text{ time} \times \text{Velocity}.$$

(Where t is in seconds, D is in meters, and V will be expressed in meters per second)
The time between the sending of the signal and the receiving of the echo may be calculated by using the formula:

$$t = \frac{2\ D}{V}$$

$$\text{time} = \frac{2 \text{ Distance}}{\text{Velocity}}.$$

Calculate the time required for each depth given on the data sheet. (assign certain problems to specific students and compile the individual results for use with the graph)

Example Distance = 975 meters

Velocity = 1524 meters/second

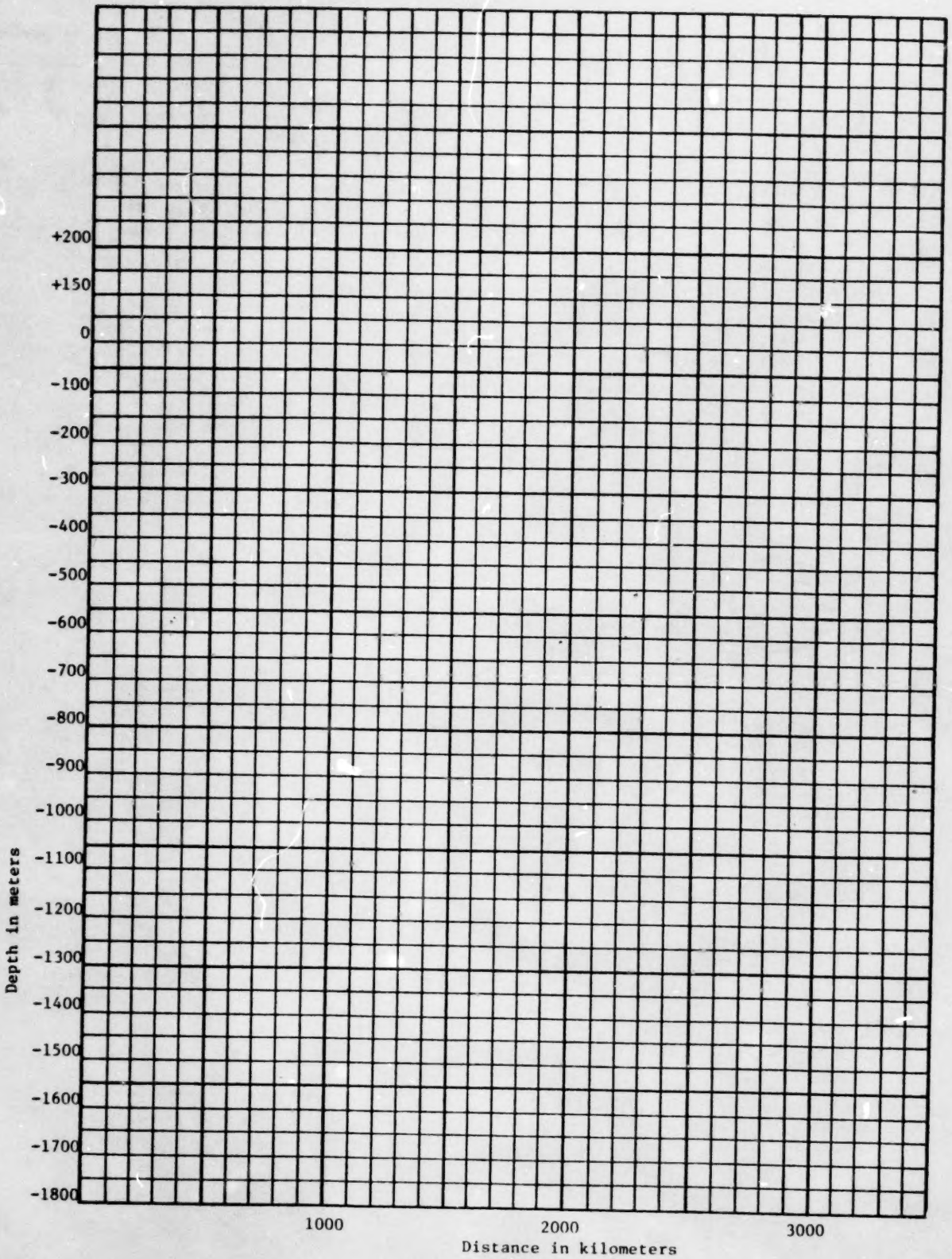
Time = t

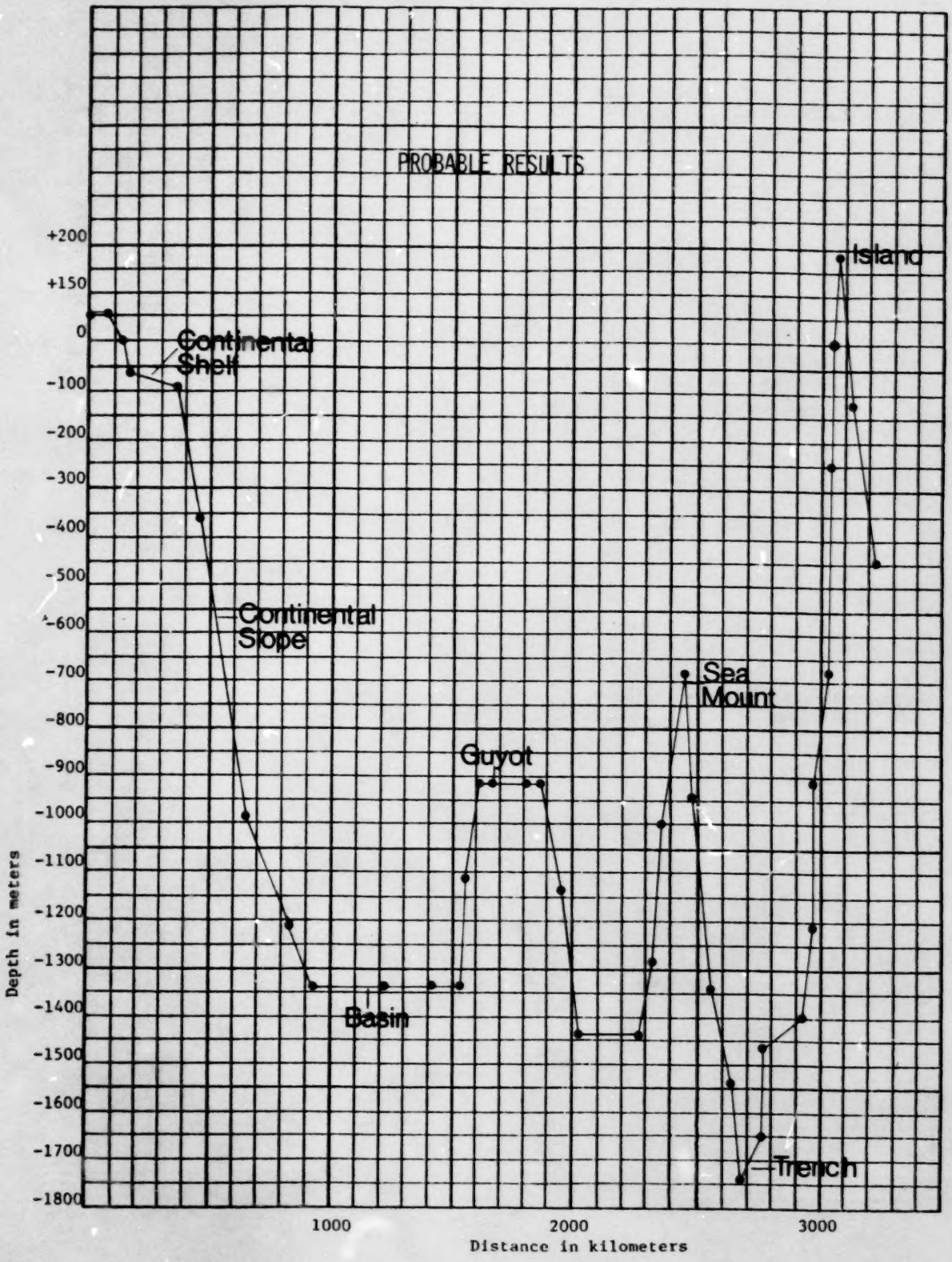
$$t = \frac{2 \times D}{\text{Velocity}}$$

$$t = \frac{2 \times 975 \text{ m}}{1524 \text{ m/s}}$$

$$t = \frac{1950 \text{ m}}{1524 \text{ m/s}}$$

$t = 1.279$ seconds


+200
+150
0
-100
-200
-300
-400
-500
-600
-700
-800
-900
-1000
-1100
-1200
-1300
-1400
-1500
-1600
-1700
-1800
Depth in meters
1000
2000
3000
Distance in kilometers


PROBABLE RESULTS
+200
+150
0
-100
-200
-300
-400
-500
-600
-700
-800
-900
-1000
-1100
-1200
-1300
-1400
-1500
-1600
-1700
-1800
Depth in meters
Continental Shelf
Continental Slope
Basin
Guyot
Sea Mount
Island
Trench
1000
2000
3000
Distance in kilometers

TITLE: Oceanography: Simulation Game - "Seaside City"

Adapted from:
Exploring Inner Space
Mathematics & Science Center
Glen Allen, VA 23060

PURPOSE: To play a land use simulation game involving a city located on an important estaury.

MATERIALS:

1. copies of Task A, B, and D (found at end of this unit)
2. 8 large unlined sheets paper

PRE-LAB: (Time: Three 50 minute class periods)
Review with students what will take place in the allotted time. Discuss inferring, recording, and classifying possible uses of land.

PROCEDURE:

Part I.

A. Distribute a copy of Task A to each student.

B. The problem to be decided is, "What are some of the possible uses for the one square kilometer plot of vacant land that has been recently purchased by the city?"

C. What are some possible uses for the undeveloped land? As students respond, write all comments on the board just as they state them. Don't paraphrase for them unless they are too wordy. If students give major categories right away, such as Recreation, or Industry, ask for examples of each category. Number the items as you go along - to simplify identification later. When you get 15 or 20 items, STOP.

D. Which of these uses are similar? Designate similar uses by letters - A, for all of one type; B, the next; and so forth. When most uses are designated, or the group seems to run out of ideas, STOP. It's okay to change the groupings if the students change their minds along the way.

E. What label could we give to all the items in A? What label could we give to Group B? (Recreation, Industrial, Utilities, Housing, Commercial). It is appropriate if students suggest more than one use for a group. All uses should be written down.

Part II Developing and Giving Presentations

A. Divide the class into groups based upon the number of categories decided on in "E" above. There should not be more than 4-5 people in each group. Assign each group to one of the use categories.

B. Each group is to represent the special user group assigned.

C. Distribute Task B form and inform the students that they have 10 minutes to list and analyze possible uses for the vacant land in the assigned category. They should consider those listed on the board for their category plus any other possible uses they can think of for the category.

Instruct students:

Procede with Task C. They have 20 minutes to plan a strategy and develop a 3-minute presentation to be made to the City Planning Board. This presentation should be a proposal for developing the undeveloped area. They should have a visual display that outlines and illustrates their proposal for development. Note: Each group should now receive a sheet of the unlined paper on which to diagram their proposed land usage.

D. More than one person in each group should help in making the 3-minute presentation. Ten minutes into Task C, have each group select one of its members to meet together as the City Planning Board. Instruct the members that they will be responsible for hearing the presentations and deciding upon the best one. Instruct them that their job in the next 10 minutes is to:

1. Make a copy of the criteria they will use in evaluating the proposals;
2. Elect a chairman to preside during the group presentations;
3. Develop a rating scale (i.e., a 1-5 scale with 1 being "very undesirable" and 5 representing "very desirable").

CRITERIA

Presentation	Environmental Impact	Advantages to the people	Need	Cost
1. 2. 3. 4. 5. 6. 7.				

E. Twelve minutes after the groups start planning Task C, remind them they have 8 minutes left to have their presentation ready. Let the groups have an additional minute to finish if needed.

F. Have the city planning board sit up front. Appoint a timekeeper to limit presentations to 3 minutes (give 2-minute warning). Announce that because of time, there will be no rebuttals or discussion. The Board may want to ask questions or have rebuttal time after all presentations. However, allow only 5-10 minutes for this part.

G. After Part F is finished, the Board should retire for 5-10 minutes to select the best proposal.

H. While the Board is meeting, each small group should develop a list of criteria they think should be used in choosing between the plans submitted.

I. Seaside City Planning Board announces its decision and gives reasons for the decision.

J. Seaside City Planning Board reads the criteria for selection aloud.

CONCLUSION:

1. Did new leadership emerge during this session? What factors enabled this to happen?

2. Did your group work as a team? What did your group do to insure participation by all members of the group?

3. What important things happened in the groups? How did you feel as a group member? How do you evaluate the criteria used?

Note:
This is one of the most important parts of the activity because it emphasizes that we need a variety of information and data before we can intelligently make a land management or environmental decision to best meet the needs of people and their environment. This question list has the elements that need to be considered in studying a local environmental issue or concern. It also includes elements of all the curriculum subject areas (social studies, science, language arts, etc.).

TASK A (10 minutes) Work by yourself

Read the background information for Seaside City, and then list some possible uses for the vacant land.

One square kilometer of unused county land located near Bluenose Bay four kilometers of the city is now available for the city's use.

BACKGROUND INFORMATION SHEET: SEASIDE CITY

The population is 150,000 and rapidly increasing.

The city's boundaries are being extended, but the suburban fringe is expanding even more rapidly.

Adequate highway access and a skilled labor force are available.

The city is located on the south side of Bluenose Bay.

The land to the west is devoted mainly to farming.

The Cod River is unpolluted and is a source of both commercial and sport fishing.

Industrial and electrical generating plants in the area are dependent exclusively on fuel oil as an energy source.

Seaside City has an existing deepwater port and the depth of the water near the available land is sufficient for port facilities.

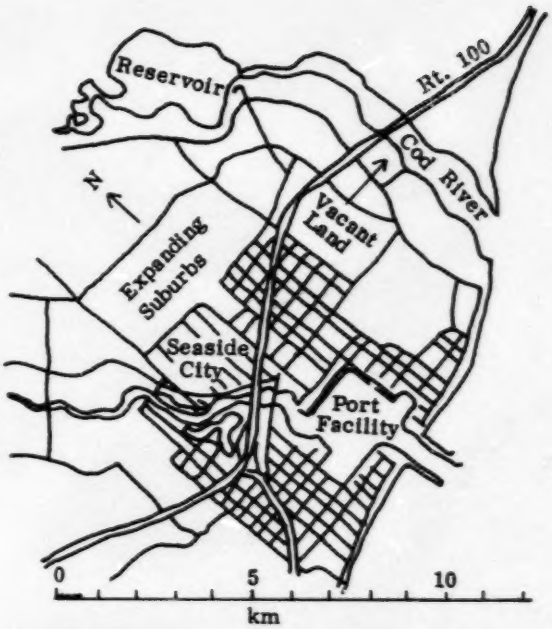
The area is a source of sand and gravel for construction.

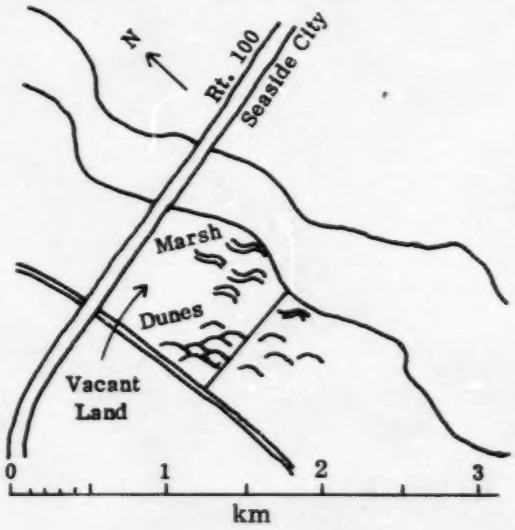
The present sewage treatment plant and garbage disposal area are at maximum capacity.

The citizens of Seaside City are concerned about the maintainance of a scenic regional environment.

The county board of control is the authority for land zoning, and many citizen's groups are developing to influence zoning decisions.

List below possible uses of the land:





TASK B: (10 minutes) Group_____Assigned Category of Land Use_____

Your task is to analyze and list possible consequences of different land uses within your assigned land use category.

Use	Advantages for land/people	Disadvantages to land/people

TASK C: (20 minutes)

Develop a strategy and method to present your plan of development to the City Planning Board or appropriate local authorities.

TITLE: Earth Science Bingo Instructions

Sharon Charles
Stonewall Jackson Junior High
Mechanicsville, Virginia 23111

OBJECTIVE: To provide an entertaining review of earth science terms.

MATERIALS:

1. 50 earth science terms
2. "Bingo Boards"
3. small, colored paper squares
4. pencil
5. words and definitions for teacher

PRE-LAB PREPARATION: Teacher must run off one board for each student. Colored paper cut on a paper cutter can be used for chips. (Suitable substitutes may be used). A list of 50 words should be written on the blackboard or written on paper and handed out to each student. This exercise can be completed in one 55 minute class period.

PROCEDURE:

1. Give each student 1 blank "board" and a handful of "chips". List the 50 terms on the board or list them on a handout sheet. The student should randomly fill his board with only 24 of the 50 terms, leaving the middle space free. No two boards should be alike. (Collect handouts for future use.)
2. The teacher should pick a definition from a "hat" and the student should cover the correct corresponding answer on his board.
3. Prizes for each game are encouraged. There should be approximately five winners per class period. A candy bar is great incentive to win!
4. Variations can be played, for example, 4 corners, T, cover the board, or regular Bingo.
5. Hints: At Christmas, a small candy cane may be drawn on the back of one board. Towards the end of class, this candy cane may be used to identify the winner of a door prize. (Teacher should decide the item to be given as a door prize).

B	I	N	G	O
		FREE		

Oceanography Bingo Items

Marlene Brewer
Mathematics & Science Center
Glen Allen, VA 23227

1. abyssal plain - relatively flat area of the ocean basin with very little relief.
2. Antarctic Bottom Water - the very cold, dense water mass formed in the vicinity of Antarctica and found on the floor of the great ocean basins.
3. atoll - a ring-shaped island usually of coral limestone, nearly encircling a lagoon.
4. backshore - that part of the beach which is usually dry, being reached only by the highest tides, and by extension, a narrow strip of relatively flat coast bordering the sea.
5. backwash - water or waves thrown back by an obstruction such as a ship, breakwater, cliff, etc., or the seaward rushing flow of water down the foreshore of the beach
6. barrier island - an island formed generally parallel to the coastline and separated from the mainland by a sound or lagoon.
7. barrier reef - a coral reef parallel to and separated from the coast by a lagoon that is too deep for coral growth.
8. bathythermograph - a device for obtaining a record of temperature versus depth in the ocean usually used from a ship underway.
9. beach - the zone of unconsolidated material along a shoreline; the zone where the deposited material is in active transit during a year period.
10. beach profile - the intersection of the ground surface with a vertical plane; may extend from the top of the dune line to the seaward limit of sand movement.
11. berm - the nearly horizontal portion of a beach or backshore having an abrupt fall and formed from the deposition of material by wave action, and marks the limit of ordinary high tides.
12. brackish water - water in which salinity values range from approximately 0.50 - 17.00 parts per thousand.
13. breaker - a wave breaking on the shore, over a reef, etc.
14. breakwater - a wall-like structure erected at the edge of the surf zone to absorb wave energy.
15. Canary Current - the prevailing southward flow along the southwest coast of Africa.
16. cape - a point of land jutting from a continent or large island which prominently marks a change in or interrupts the coastal trend.
17. carbonates - a class of carbon compounds used in the shells and skeletons of some marine animals.
18. channelization - the dredging of channels to maintain a certain water depth in navigable waters.
19. continental rise - a gentle slope with a generally smooth surface rising toward the foot of the continental slope.
20. continental shelf - comparatively shallow ocean bottom bordering a coast extending from the low water line to the depth at which there is usually a marked increase of slope to greater depth.
21. continental slope - relatively steep slope leading from the outer edge of the continental shelf to the deep ocean basin.
22. convection current - the forcing of a mass of lighter warm water to the top in a continuous movement.
23. coral - the hard calcareous skeleton of various anthrozoans and hydrozoans.

24. Coriolis effect - an effect on moving particles resulting from the earth's rotation. It causes particles to be deflected to the right of motion in the northern hemisphere and to the left in the southern hemisphere.
25. desalination - the process by which enough dissolved salts are removed from sea water to render it drinkable.
26. dinoflagellates - a class of single-celled or minute organisms which may exhibit plant and animal characteristics.
27. diurnal tide - a tide whose period is approximately one lunar day (24.84 hours).
28. doldrums - a nautical term for the equitorial trough, with special reference to the light and variable nature of the winds.
29. ebb tide - the portion of the tide cycle between high water and the following low water.
30. eddy - a circular movement of water usually formed where currents pass obstructions.
31. estuary - an area of the sea where the salinity of the water is considerably diluted.
32. fiord - a long, narrow, steep-walled bay where a glacial valley was eroded below sea level.
33. globigerina - a common form of sediment-producing foraminiferan.
34. Gulf Stream - the name given to the system of currents including the Florida current, Gulf Stream, and North Atlantic Drift.
35. guyot - deeply submerged volcanic cone with broad, flat top. Also known as a tablemount.
36. inlet - a short, narrow waterway through a barrier connecting a bay or lagoon with the sea.
37. lagoon - a shallow sound, pond, or lake generally separated from the sea.
38. longshore current (littoral current) - the current found in the surf zone resulting from waves approaching the beach at an angle.
39. Nansen bottle - a device used by oceanographers to obtain subsurface samples of sea water.
40. neap tide - tide of decreased range which occurs about every two weeks when the moon is in quadrature.
41. offshore - the comparatively flat zone of variable width which extends from the outer margin of the rather steeply sloping shore face to the edge of the continental shelf.
42. phytoplankton - the plant forms of plankton.
43. red tide - a red or reddish-brown discoloration of surface waters, most frequently in coastal region, caused by concentrations of certain microscopic organisms, particularly dinoflagellates. Toxins produced by the dinoflagellates can cause mass kills of fishes and other marine animals.
44. rift valley - the valley lying between the crests of the oceanic ridge systems.
45. salinity - a measure of the amount of dissolved salts in sea water.
46. salt-wedge estuary - an estuary in which a wedge of sea water causes a pronounced increase in salinity from surface to bottom.
47. sea breeze - a light wind blowing toward the land caused by unequal heating of land and water masses.
48. seamount- an elevation rising 1,000 meters or more from the sea floor and of limited extent across the summit.
49. secchi disc - a simple device used to estimate water clarity.
50. shoreline - the narrow strip of land in immediate contact with the sea, including high and low water lines.
51. spring tide - tides of increased range which occur about every two weeks when the moon is new or full.

52. submarine canyon - a relatively narrow, deep depression with steep slopes the bottom of which grades continuously downward.
53. surf zone - the area in which surface waves approaching a shoreline break.
54. thermohaline - pertaining to both temperature and salinity acting together.
55. tombolo - a bar connecting or tying an island to the mainland or to another island.
56. trench - a long, narrow, and deep depression of the sea floor with relatively steep sides.
57. tsunami - a long-period sea wave produced by a submarine earthquake or volcanic eruption.
58. typhoon - a storm similar to a hurricane, but found along the western margin of the Pacific.
59. upwelling - an upward movement of cool water along a coast to replace warm surface water blown away by the wind.
60. water mass - a body of water usually identified by its T-S (temperature-salinity) curve or chemical content.
61. wave amplitude - the vertical distance from still water level to the wave crest equal to one-half the wave height.
62. wave crest - the highest part of a wave.
63. wave height - the vertical distance between a wave crest and the preceding wave trough.
64. wave length - the horizontal distance between points on two successive waves measured perpendicularly to the wave crest.
65. wave period - the time, in seconds, required for a wave crest to traverse a given distance.

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APPENDIX - SOLAR HEATER POSTER - REMOVED
DUE TO IRREPRODUCIBILITY